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Oil Shale Office
U.S. Geological Survey
1831 North 6th St. Suite 300
Grand Junction, CO 81501

OIL SHALE TRACT C-A

SUPPLEMENTAL MATERIAL TO REVISED DETAILED DEVELOPMENT PLAN

SUBMITTED BY

GULF OIL CORPORATION

STANDARD OIL COMPANY
(INDIANA)

TN
659
.C64
R382
1977
v.3

88064984

TN
859
.C64
R362
1977
C.3

RIO BLANCO OIL SHALE PROJECT

DAYTON COMMONS 9725 E. HAMPDEN AVENUE
DENVER, COLORADO 80231 303-751-2030

September 2, 1977

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Mr. Peter A. Rutledge
Area Oil Shale Supervisor
USDI - Geological Survey
131 N. 6th - Suite 300
Grand Junction, CO 81501

Dear Mr. Rutledge:

In response to your request based on your review of the Revised Detailed Development Plan (DDP), enclosed are the following supplemental materials to be attached and considered a part of the Revised DDP:

1. Errata Sheets.

2. Description of Revised Method for Sinking Shafts (Section 2, Chapter 6).

3. Revised Retort Geometry (Section 2, Chapter 6)

4. Supplemental Information for

   a. Modular Development Phase and Commercial Phase Sulfur Balance (Section 3, Chapters 2 and 3).

   b. Processed Shale Disposal (Section 4, Chapter 2).

   c. Transportation (Section 5, Chapter 2).

   d. Air Quality Control (Section 6, Chapter 5).

   e. Water Quality Control (Section 6, Chapter 6.

   f. Modular Development and Commercial Phase Water Balances (Section 6, Chapter 6)

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g. Effect of Underground Retorts on Groundwater (Section 6, Chapter 14).

h. Hydrology Impact Assessment (Section 7, Chapter 6).

5. Scope of Work, RBOSP Modular Development Phase Monitoring Program (August 17, 1977).

Yours very truly,

J. Blaine Miller

LIW:ge
Enclosures

Errata to DDP

Section 1

		Was	Should be
P. 1-5-6	Last line	water courses...	water courses.
P. 1-7-7	Par. 2, line 4	..Colorado Category II..	..Category I...
P. 1-6-13	Col.: Maximum Predicted ...Increment... Row: NAAQS, NO_2	11	13.6
	Col.: Predicted Off Site Row: NAAQS, NO_2	13	15.6

Errata to DDP

Section 2

Page 2-6-5 Page 2-6-14 Page 2-6-20	Figures 2-6-9a and 2-6-2 show three entries to Retort No. 5 on the "B" level, while figure 2-6-7 shows only two entries. Only two and not three entries will be driven to Retort No. 5 on the "B" level. Figure 2-6-7 is correct.	
	Was	Should be
Page 2-6-42, line 28	Dawsonite	Dawsonite-bearing oil shale
Page 2-6-4, last line	15 feet in diameter	15 feet in finished diameter
Page 2-6-7, line 4, 5	7 feet in diameter	6 feet finished diameter
Page 2-6-10	The 110' dimension shown (both views) should be 115'.	

Errata to DDP

Section 3

		Was	Should be
P. 3-3-33,	Col.: Preheat System Row: Firing Duty	307	921
	Col.: Steam Superheater... Row: Firing Duty	13	39
	Col.: Shale Moisturizing Row: Particulates, lb/hr	10	30
	Col.: Power Generation Plant Row: Grains/ACF	0.1	0.01
P. 3-2-14	Table 3-2-3 Col.: Se Row: Raw Shale, ppm	$\bar{x}$ $s_{\bar{x}}$ 11.4 3.4	$\bar{x}$ $s_{\bar{x}}$ 7.8 0.78
P. 3-3-13	Lower righthand corner	Fowl Water to Steam Stripping	Foul Water to Steam Stripping

Errata to DDP

Section 5

		Was	Should be
P. 5-4-7	2nd paragraph, line 2	..valve);	...valve); a station approximately one mile west of the pumping station; at the....

Errata to DDP

Section 6, Chapter 5

	Was	Should Be
p. 6-5-35, line 15	10,000 ft MSG are...	10,000 ft MSL are...
line 24	..intersector...	...intersection...
p. 6-5-42, line 24	$+\exp\left\{-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right\}\Big]$	$+\exp\left\{-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right\}\Big]$
p. 6-5-43, line 7	..wind speed and ambient...	..wind speed, wind direction and ambient...
p. 6-5-43, lines 27-30	"The equations... category."	remove
p. 6-5-48, line 9	insert - The AQPUF2 grid is subdivided into 2 km x 2 km grid squares.	
p. 6-5-49, line 28	"...puff segment.."	"...plume segment.."
p. 6-5-50, line 4	",10m level wind speed.."	",30m level wind speed.."
p. 6-5-56, Title	Jan. 1, 1976	Jan. 22, 1976

p. 6-5-67

Primary NO_2 Maximum Predicted Off-site Increment Due to Development ($\mu g/m^3$)	13.6
Predicted Off-Site Value ($\mu g/m^3$)	15.6

Note: The asterisk should only apply to the Particulates annual standard.

p. 6-5-91, line 2 after Table: CRS → CRSTER

p. 6-5-91
Table 6-5-30

TABLE 6-5-30
PREDICTED MAXIMUM CONCENTRATIONS FOR CO AND NO_X
ASSOCIATED WITH VENTILATION EMISSIONS

Downwind Distance (km)	CO ($\mu g/m^3$) 1-hour	CO ($\mu g/m^3$) 8-hour	NO_X ($\mu g/m^3$) Annual
1.5	47	16	1.1
3.0	34	11	1.6
6.0	20	7	9.7
8.0	17	6	6.8
10.0	17	6	4.9

	Was	Should be
p. 6-5-94, line 6	...(9/1/74-8/31/76).	...(9/1/75-8/31/76).
p. 6-5-94, line 14	...obtain conservative...	...obtain most realistic...
p. 6-5-10 Column: Operation Row: 2	Overland conveyor transfer points(3)	Overland conveyor transfer points (3)
Column: Operation Row: 6	...&Screening(2)...	...& Screening Building Transfer Point (2)
Column: Operation Row: 12	Reserve...Points(2)	Reserve...Points(2)
Column: Operation Row: 16	Feedstock...Points(2)	Feedstock...Points (2)
P. 6-5-11, line 8 line 13 line 26, (3rd from bottom)	0.01% 0.002% 0.22%	0.005% 0.01% 0.002%
p. 6-5-12, line 12	0.07%	0.002%
p. 6-5-18 Column: Preheat System Row: Firing Duty	307	921
Column: Steam Superheater... Row: Firing Duty	13	39
Column: Shale Moisturizing Row: Particulates, lb/hr	10	30
Column: Power Generation Plant Row: Grains/ACF	0.1	0.01
p. 6-5-41 Column: Part. Emission Rate Row: Stack 3	1.26	3.78
p. 6-5-40 Column: SO_2 Emission Rate Row: Stack 2	9.4	7.8
P. 6-5-13, last sentence	Guideline.....have been developed.....	Guideline.....will be developed.....

Errata to DDP

Section 6, Chapter 6

Page 6-6-6, Figure 6-6-2	A line from the Mine Service Area Retention Pond to the Process was inadvertently omitted and should be added.

Errata to DDP

Section 6, Chapter 8

Page 6-8-15, last line 6-8-16, top line	Omit sentence "The size distribution . . . in Section 2, Chapter 6.4."
Page 6-8-29	In Table 6-8-5, the subheading "shrubs" should be located between "common daisy" and "big sagebrush."

	was	should be
Page 6-8-33, line 14	1.0 X 0.5 m	1.0 X 1.0 m subplots

Errata to DDP

Section 6, Chapter 11

	was	should be
Page 6-11-3, last line	"44 acres"	"54 acres"
Page 6-11-6, line 5	"427 acres"	"417 acres"
line 10	"44 acres"	"54 acres"
line 15	"44 acres"	"54 acres"
line 18	"427 acres"	"417 acres"
Page 6-11-7, line 15	"261 acres"	"251 acres"
line 30	"261 acres"	"251 acres"
Page 6-11-8, line 2	"261 acres"	"251 acres"
line 11	"1027 acres"	"1037 acres"
Page 6-11-15, line 3	Delete ". . . domestic and feral. . ."	
Page 6-11-18, line 1	"1475 acres"	1454 acres"
Page 6-11-26, line 20	". . .10 transects/ site. . ."	"1 transect/5 acres. . ."
Page 6-11-27, line 19	". . .will also be determined. . ."	". . .will be reevaluated. . ."
Page 6-11-28, line 7	". . .determined. . ."	". . .evaluated. . ."
line 12	". . .the Modular Development Phase. . ."	". . .habitat enhancement. . ."
Page 6-11-29, line 9	". . .determined. . ."	". . .reevaluated. . ."
line 23	". . .determine. . ."	". . .reevaluate. . ."

Errata to DDP

Section 7, Chapter 2

	Was	Should be
Page 7-2-46, line 8	"Some fluctuations were noted but, for the most part, these parameters remained stable throughout the study period."	"Fluctuations in the dominant aquatic taxa were noted during the study, but the species composition remained relatively stable throughout the period."
Page 7-2-47, line 20	". . .most. . ."	". . .as most. . ."

Errata to DDP

Section 7, Chapter 3

	Was	Should be
Page 7-3-1, line 8	". . .20mg/m^3. . ."	". . .20µg/m^3. . ."

Errata to DDP

Section 7, Chapter 4

	Was	Should be
Page 7-4-2, line 6	". . .44. . ."	". . .54. . ."
Page 7-4-12, line 8	". . .118 acres. . ."	". . .169 acres. . ."
Page 7-4-4, line 24	Vented mine air and powder gases will be scrubbed to meet State and Federal EPA emission standards.	Vented mine air and powder gases will meet State and Federal EPA emission standards.
Page 7-4-17, lines 14-20	...was predicted on.. the two.	...was predicted by the NUS FOG code as described in Section 5.7B of Chapter 5 in Section 6.

Errata to DDP

Section 7 - Chapter 6

	Was	Should be
Page 7-6-3, line 1	". . .determined. . ."	". . .determine. . ."

Errata to DDP

Section 8, Chapter 1

page 8-1-4

Figure 8-1-1- Column Headings are missing. The columns should be headed, from left to right, as follows:

Column 1. Affected Parameters

Column 2. Cumulative Construction Activities

Column 3. Storage of Raw Shale Ore

Column 4. Habitat Modification

Column 5. Revegetation

		was	should be
page 8-1-6	line 31	". . .benthos, and fish."	". . .and benthos."

Errata to DDP

Section 8, Chapter 4

	Was	Should be
Page 8-4-5, line 23	". . .located on tract. . ."	"located off tract. . ."
Page 8-4-8, line 25 & 26	". . .in the southwest corner of the tract. . ."	". . .southwest of tract. . ."
Page-8-4-14, line 24	". . .also be determined. . ."	". . .be reevaluated. . ."
Page 8-4-15, line 12	". . .determined. . ."	". . .reevaluated. . ."
Page 8-4-15, line 17	". . .the Modular Development Phase. . ."	". . .habitat modification or revegetation. . ."
Page 8-4-16, line 16	". . .determined. . ."	". . .reevaluated. . ."
Page 8-4-17, line 1	". . .determine . ."	". . .reevaluate . . ."
Page 8-4-18, line 11	". . .to be chosen will depend on. . ."	". . .required will be reevaluated based on. . ."
Page 8-4-18, line 22	". . .determined following the pilot study. . ."	". . .reevaluated following the first year study. . ."
Page 8-4-19, line 10	". . .determine. . ."	". . .reevaluate. . ."
Page 8-4-20, line 8	". . .pilot study. . ."	". . .first year study. . ."

Errata to DDP

Section 8, Chapter 5

	Was	Should be
Page 8-5-5, line 4	". . .±2σ. . ."	". . .±σ. . ."
Page 8-5-6, line 6	". . .±2σ. . ."	". . .±σ. . ."
Page 8-5-7, line 8	". . .±2σ. . ."	". . .±σ. . ."
Page 8-5-8, line 8	". . .±2σ. . ."	". . .±σ. . ."

Errata to DDP

Section 8 - Chapter 6

Page 8-6-2, Table 8-6-1. The table contains erroneous X's (Column 2 from left to right) Continuously or Automatically. Drop X's for limited water quality and baseline water quality for surface water.

		Was	Should be
Page 8-6-3,	line 27	". . .were to exceed. . ."	". . .exceeds. . ."
	line 28	". . .was. . ."	". . .will be. . ."
	line 31	". . .was. . ."	". . .is. . ."
	line 32	". . .was. . ."	". . .will be. . ."
Page 8-6-13,	line 4	". . .the. . ."	". . .and. . ."

Errata to DDP

Section 8, Chapter 7

	Was	Should be
Page 8-7-4, Table 8-7-1	Under Data Analyses for Soils (pH, macronutrients and micronutrients) omit Analysis of Variance (AOV) and Multiple Range Test.	
Page 8-7-5, lines 15 & 16	"(1 transect/10 acres of habitat)"	"(1 transect/100 acres of habitat)"
Page 8-7-7, lines 1 & 2	"(1 transect/10 acres. .)"	"(1 transect/100 acres. .)"
line 4	". . .determine. . ."	". . .reevaluate. . ."
Page 8-7-8, lines 7 & 8	"(1 transect/10 acres. .)"	"(1 transect/100 acres. .)"
Page 8-7-9, line 5	"(1 sample/10acres. .)"	"(1 sample/100 acres. .)"
line 25	"(1 sample/10 acres. .)"	"(1 sample/100 acres. .)"
Page 8-7-11, line 2	". . .also be determined. . ."	". . .be reevaluated. . ."
line 16	". . .determined. . ."	". . .reevaluated. . ."
line 21	". . .the Modular Development Phase. . ."	". . .revegetation. . ."
Page 8-7-12, line 19	". . .determined. . ."	". . .reevaluated. . ."
Page 8-7-13, line 4	". . .determine. . ."	". . .reevaluate. . ."
Page 8-7-13, line 26	". . .at 5-year intervals. . ."	". . .annually. . ."

DESCRIPTION OF REVISED METHOD FOR SINKING SHAFTS

The current Detailed Development Plan on page 2-6-7 describes the Development Method for the Service-Production and Ventilation Shafts for the Modular Development Phase. As outlined therein, the 7 ft. diameter Ventilation Shaft would be blind bored and the 15 ft. diameter Service and Production Shaft would be upreamed from it.

In further examining the problem, RBOSP has concluded that it will be advantageous to sink the Service and Production Shaft conventionally. The shaft will be concrete lined by slip forming in the usual manner. The depth of the shaft has been reduced from 1185 feet to 950 feet below the collar. The Ventilation Shaft will be upreamed in two lifts from its total depth to C level and from C level to surface

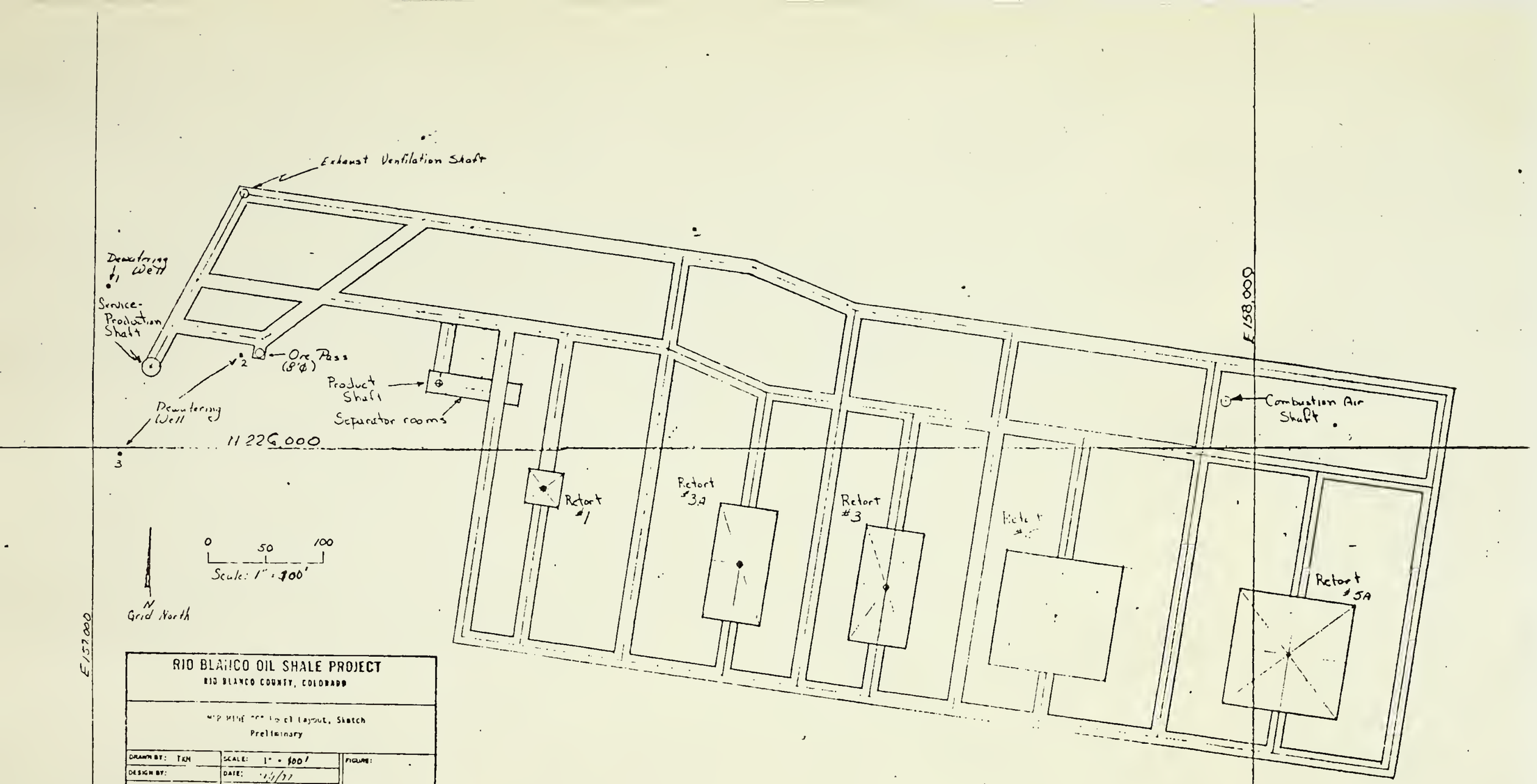
REVISED RETORT GEOMETRY

Retort geometry for the first retorts has been altered slightly to better serve the purposes of the Modular Development Phase and to allow rubblization by an approach resembling sublevel caving at an earlier stage. The present arrangement of the retorts is shown on the attached sketch. The dimensions and location of Retort No. 1 remain unchanged from the DDP as last submitted. The unusual numbering pattern is our usage and there is no Retort No. 2 or 4. Retorts 3 and 3A will be 50'x100'x140' high. Retorts 5 and 5A will be 100'x100'x400' high. The ventilation pattern remains unchanged.

As stated in the DDP, the decision point for judging the technical, economic and environmental viability of the project will be made after evaluating the burn of the fifth retort which is 400' high. The dimensions of the commercial size retort will be based on results of the fifth retort burn and will be scaled up by modeling. As stated in the the DDP, plans are to evaluate the viability of 750' high retorts for the Commercial Phase. The remining prototype retorts, 6 and up, which will be 400' high, will be developed and burned during the period when the construction for the Commercial Phase is occurring, 1982-1986.

Additional engineering design has shown that the maximum producing rate during the Modular Development Phase will be limited by the capacities of the surface equipment considered optimum for the MDP investigations and will be on the order of 1,000 barrels a day. Because the commercial decision cannot be made until 1982, large scale equipment cannot be intelligently specified and ordered before that date. Engineering design, procurement, installation and testing of this equipment as a part of the commercial development program is planned to be completed in accordance with the schedule in the DDP. RBOSP anticipates meeting the planned schedules and rates for the Commercial Phase as shown in the DDP.

Since the MDP retorts will be 400' in height, dewatering will be necessary only for the upper aquifer for these retorts. Plans for dewatering the lower aquifer will be made after the retort height is determined for the Commercial Phase and commercial development begins.



RIO BLANCO OIL SHALE PROJECT

RIO BLANCO COUNTY, COLORADO

Mine Surface Layout, Sketch

Preliminary

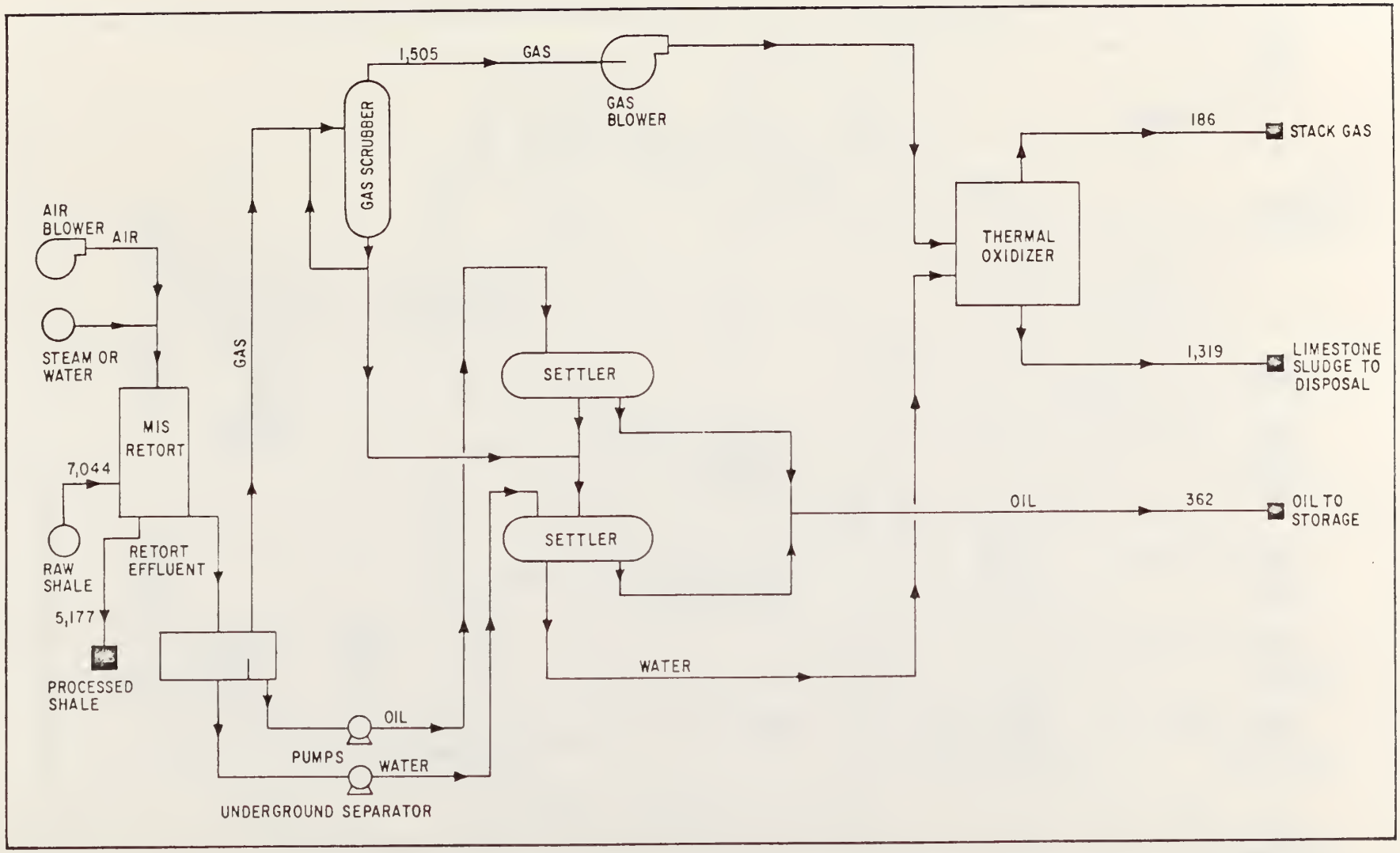
DRAWN BY: TKM	SCALE: 1" = 100'	FIGURE:
DESIGN BY:	DATE: 4/1/77	
APPROVED BY: PWM	DRAWING NO:	
		FILE:

MODULAR DEVELOPMENT PHASE AND COMMERCIAL PHASE SULFUR BALANCES (Section 3, Chapters 2 & 3)

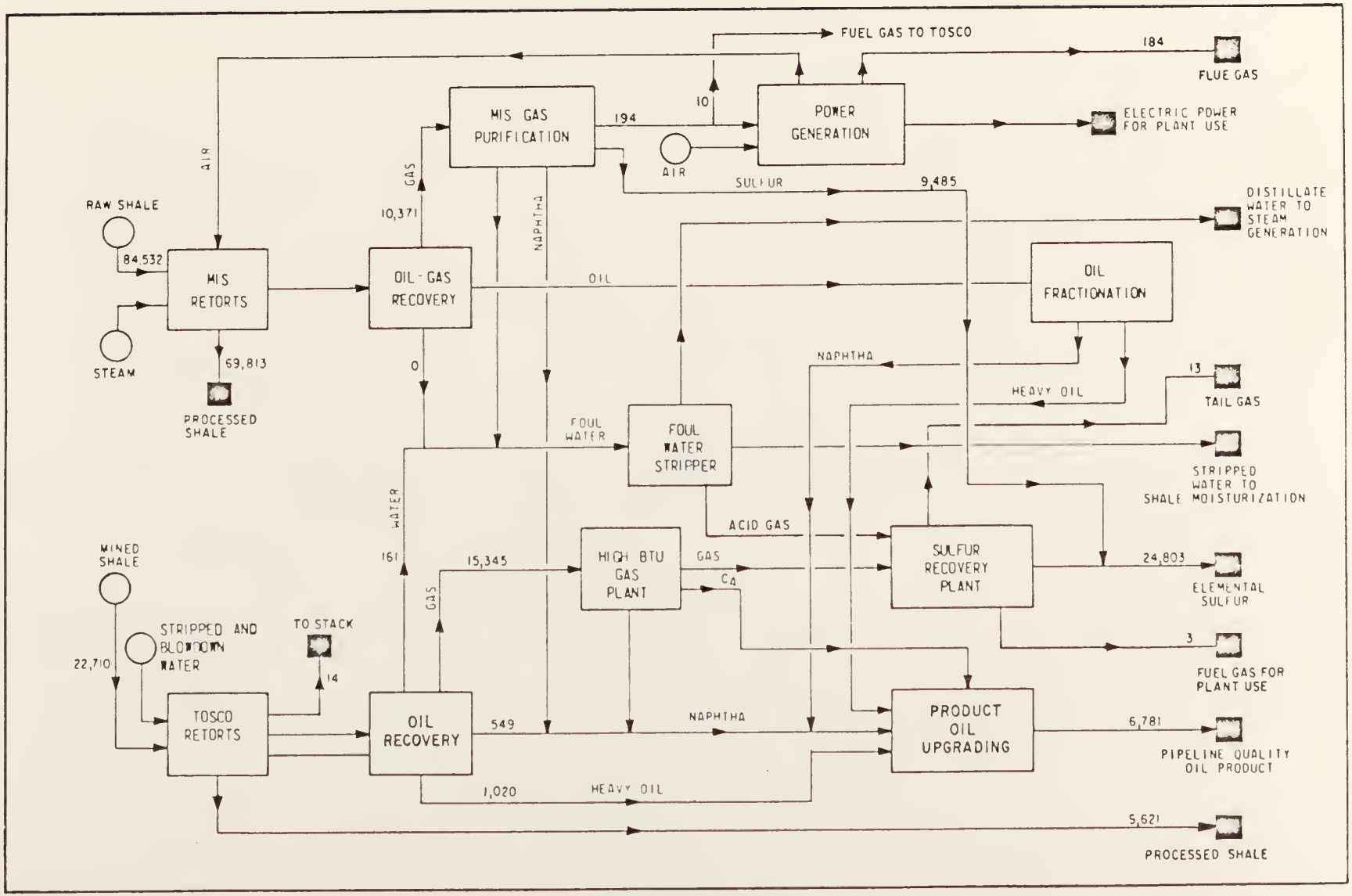
Q. Page 3-3-20. It was very difficult to determine the actual sulfur concentrations expected from the various processes during the CDP and MDP. In some instances, fuel gas was indicated as containing 50 ppm total sulfur. In other cases, tail gas clean-up was indicated as 200 ppm SO_2. In even other cases, fuel gas was indicated as containing no more than 10 ppm H_2S. Consistency among units, a sulfur balance, or at least a summary tabulation on process flow diagrams such as those pages 3-3-20, -23, and -24, would have been beneficial.

A. In the DDP, we attempted to focus on emissions from the facilities so that environmental impacts can be assessed. Attached are the sulfur balances representative of the MDP and Commercial operations.

The two attached figures show sulfur flows in lbs/hr for the Commercial and Modular Development Phases of the Project. The sulfur rates in the raw and processed shale represent total, mineral and organic, sulfur. The sulfur flows are traced either to the fuel gas system or to an emission as appropriate. Sulfur in fuel gasses is generally used in preference to tracing sulfur emissions because of the complexity of the plant fuel system. All sulfur shown going to the fuel gas system will be emitted as SO_2. In the Commercial Phase the 14 lbs/hr of sulfur going from the Tosco retorts to the stack results from the burning of an oil mist in the Tosco process. Thus the total emissions from the Tosco retorts would be this 14 lbs/hr of sulfur plus the 10 lb/hr of sulfur shown in the "fuel gas to Tosco" stream.



MODULULAR DEVELOPMENT PHASE SULFUR FLOWS LBS/HR

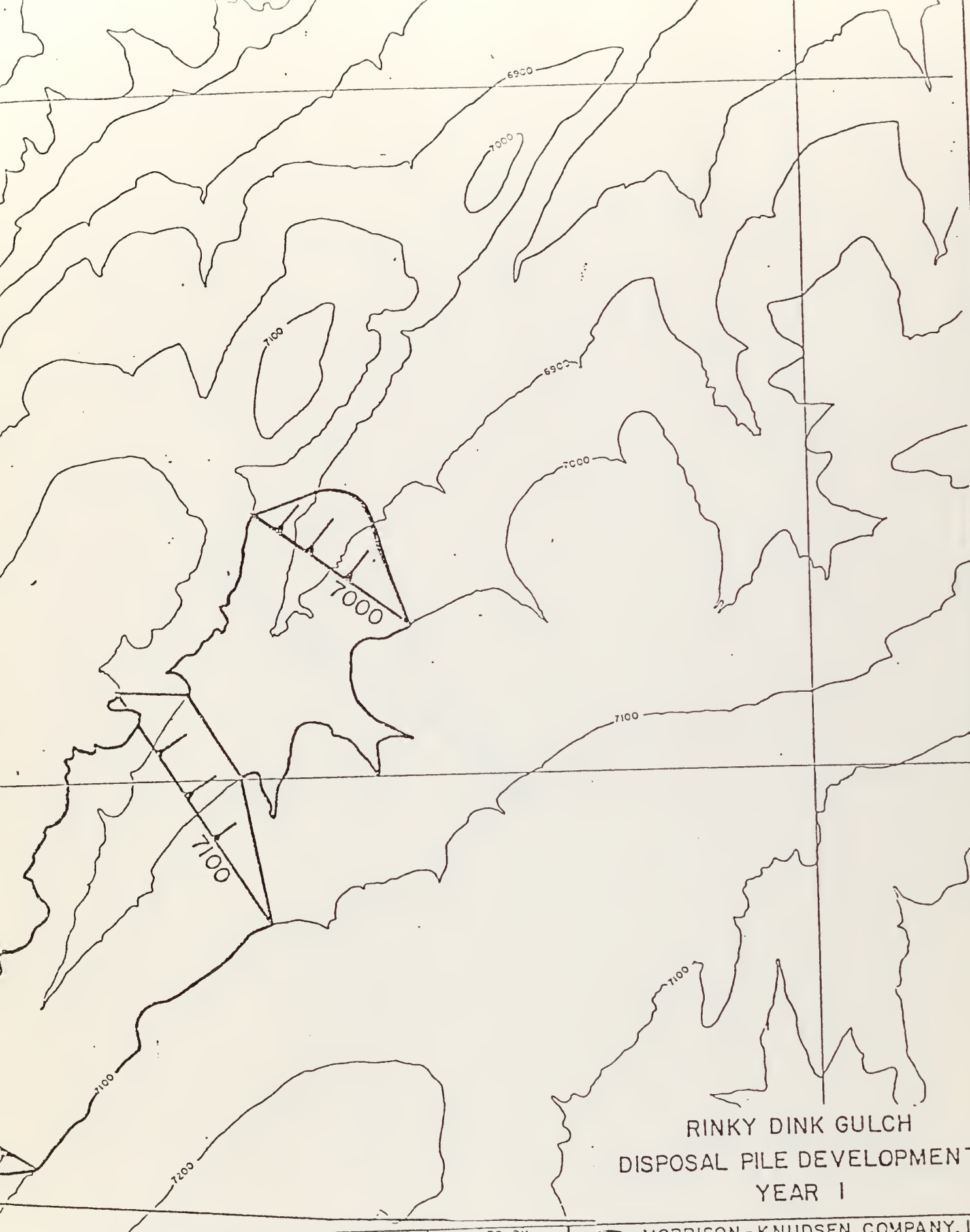


COMMERCIAL PHASE SULFUR FLOWS LBS/HR

PROCESSED SHALE DISPOSAL (Section 4, Chapter 2)

Q. The volumes and storage area required for the processed shale disposal pile are presented on page 4-2-4. What will be the sequence of pile development in terms of height and configuration? What is the planned final height, contours, and relationship to the surrounding terrain of this pile? Table 6-8-1 presents the schedule of reclamation for this pile. A discussion of this schedule in relationship to the planned pile construction is also requested to clarify the planning for processed shale disposal.

A. The attached sketches, Figures 2-10 through 2-18, show the sequence of development of the processed shale pile by time interval and show the contours. The final height, contours and relationship to the surrounding terrain are shown on the sketch, Figure 2-9, of the final pile. Table 6-8-1 shows the areas to be stripped by 5-year time intervals. Stripping will be done only as required to be just ahead of the expanding pile. Reclamation of the pile will be done as soon as portions of the pile reach final slope and/or elevation. The reclamation schedule reflects this concept.



RINKY DINK GULCH
DISPOSAL PILE DEVELOPMENT
YEAR 1

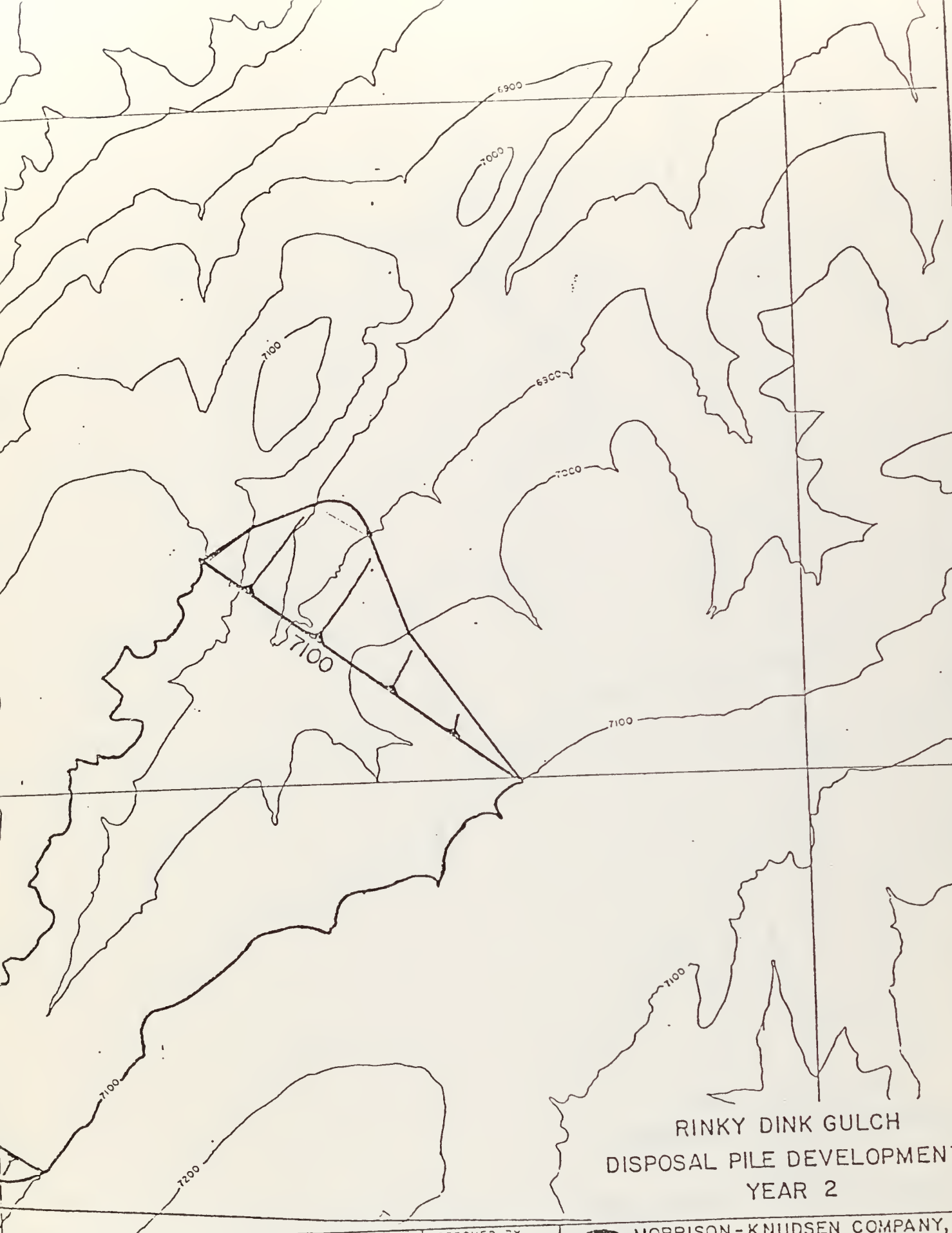
DRAWN BY J.C.	APPROVED BY [illegible] 3/10/77
CHECKED BY M.M.	SCALE NTS
CONTRACT NUMBER 1077	
SHEET NUMBER Figure 2-10	

MORRISON-KNUDSEN COMPANY, INC.

M.I.S. DEVELOPMENT
OF TRACT C-a

TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7809/BOISE, ID. 83729

MORRISON-KNUDSEN COMPANY, INC.



RINKY DINK GULCH
DISPOSAL PILE DEVELOPMENT
YEAR 2

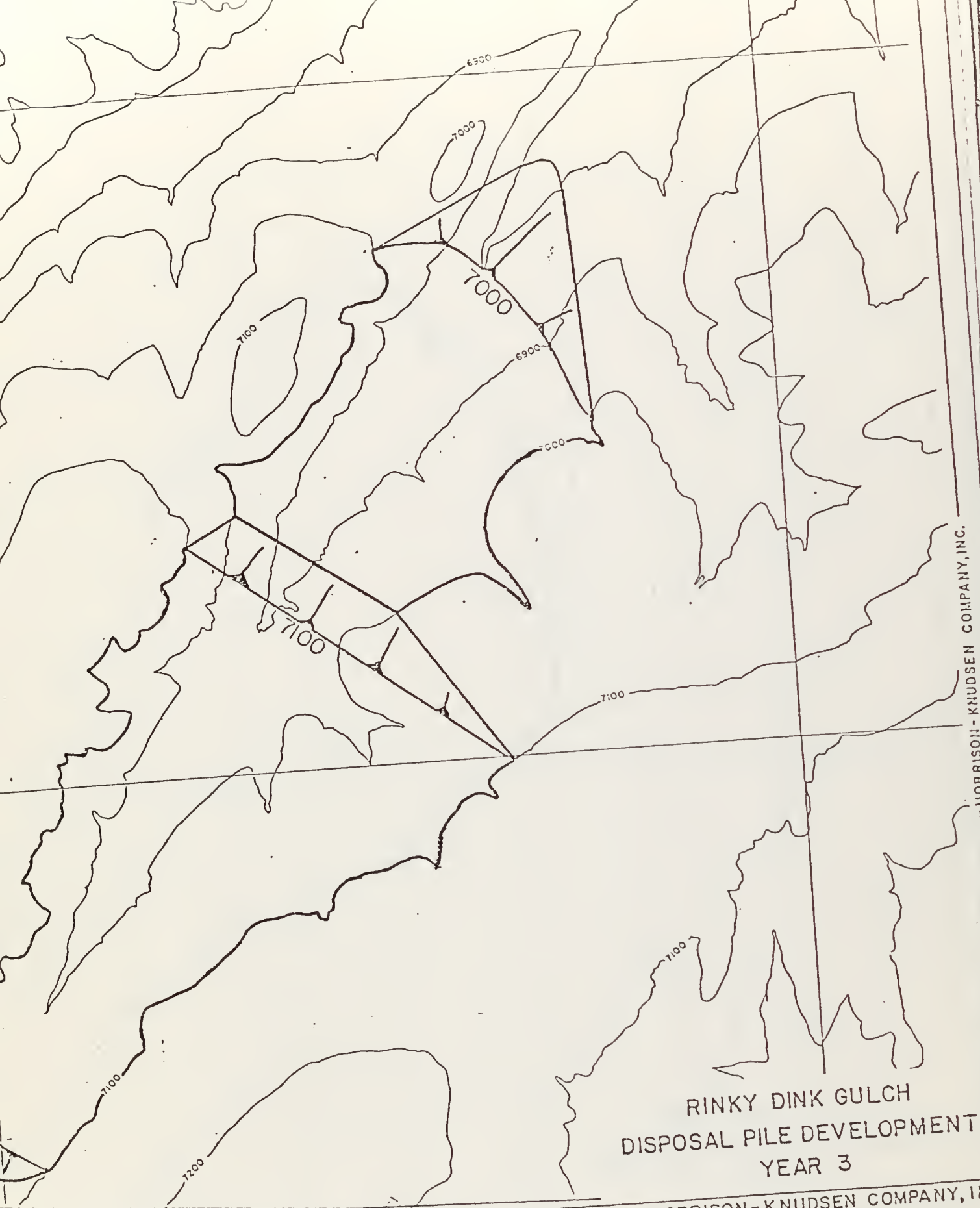
MORRISON-KNUDSEN COMPANY, INC.

DRAWN BY J.C.	APPROVED BY
CHECKED BY M.M.	SCALE NTS
CONTRACT NUMBER 1077	
SHEET NUMBER	

MORRISON-KNUDSEN COMPANY, INC.

M.I.S. DEVELOPMENT
OF TRACT C-a

MORRISON-KNUDSEN COMPANY, INC.



RINKY DINK GULCH
DISPOSAL PILE DEVELOPMENT
YEAR 3

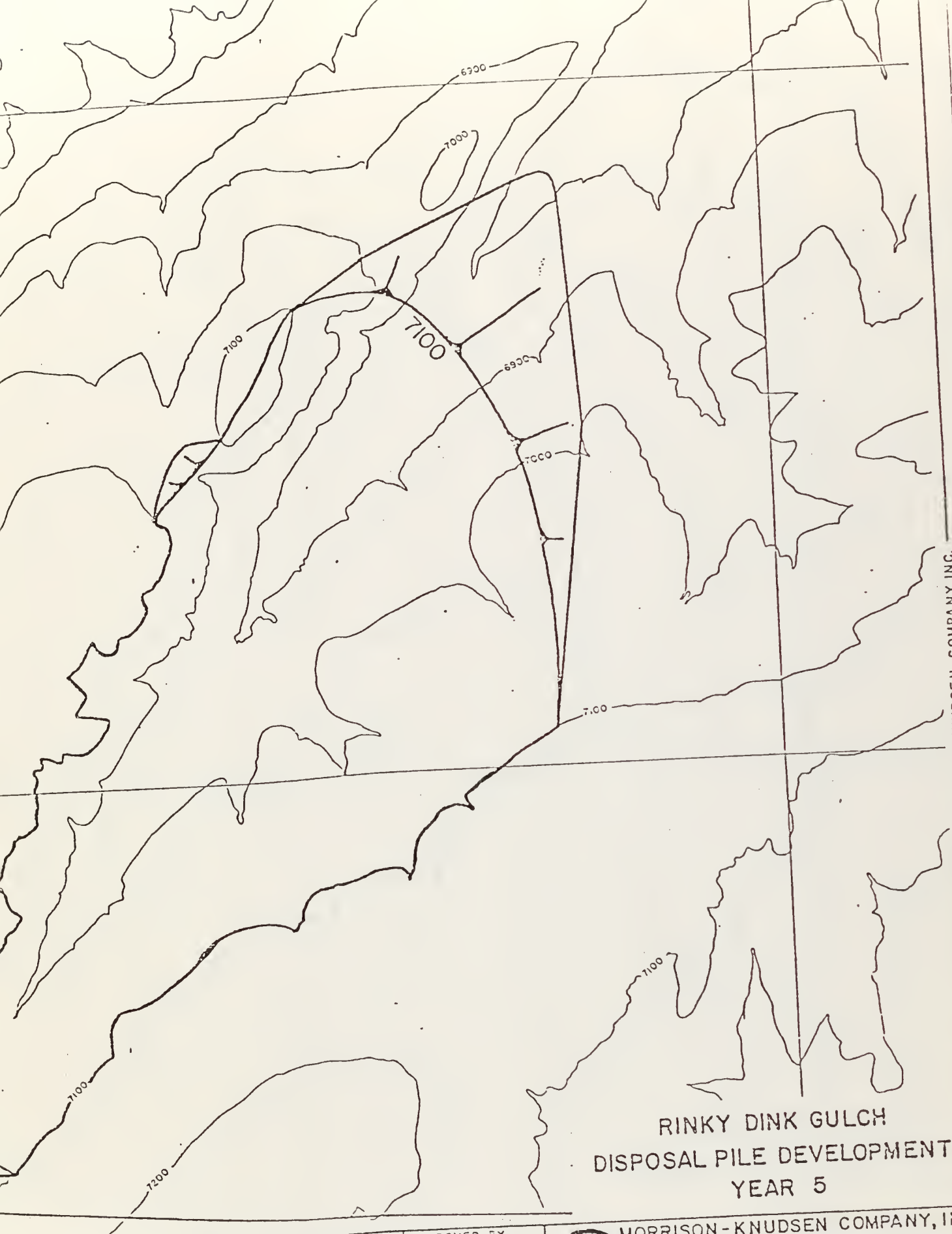
MORRISON-KNUDSEN COMPANY, INC.

DRAWN BY	JC
APPROVED BY	[signature] 3/16/77
CHECKED BY	MM
SCALE	NTS
CONTRACT NUMBER	1077
SHEET NUMBER	Figure 2-12

MORRISON-KNUDSEN COMPANY, INC.

M.I.S. DEVELOPMENT
OF TRACT C-a

TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, ID. 83729



RINKY DINK GULCH
DISPOSAL PILE DEVELOPMENT
YEAR 5

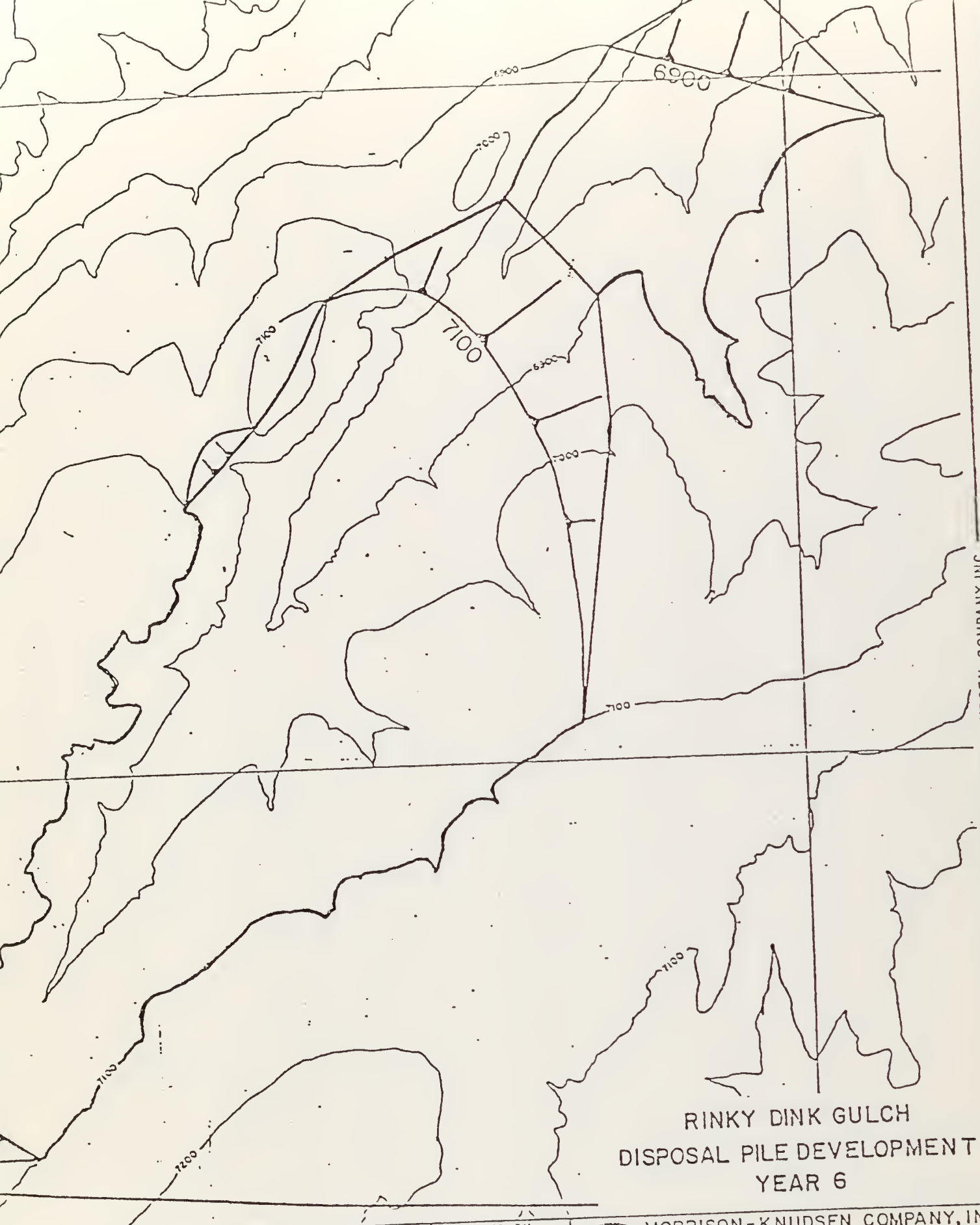
MORRISON-KNUDSEN COMPANY, INC.

DRAWN BY	JC
APPROVED BY	
CHECKED BY	MM
SCALE	NTS
CONTRACT NUMBER	1077
SHEET NUMBER	Figure 2-13

MORRISON-KNUDSEN COMPANY, INC.

M.I.S. DEVELOPMENT
OF TRACT C-a

TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, ID. 83729



RINKY DINK GULCH
DISPOSAL PILE DEVELOPMENT
YEAR 6

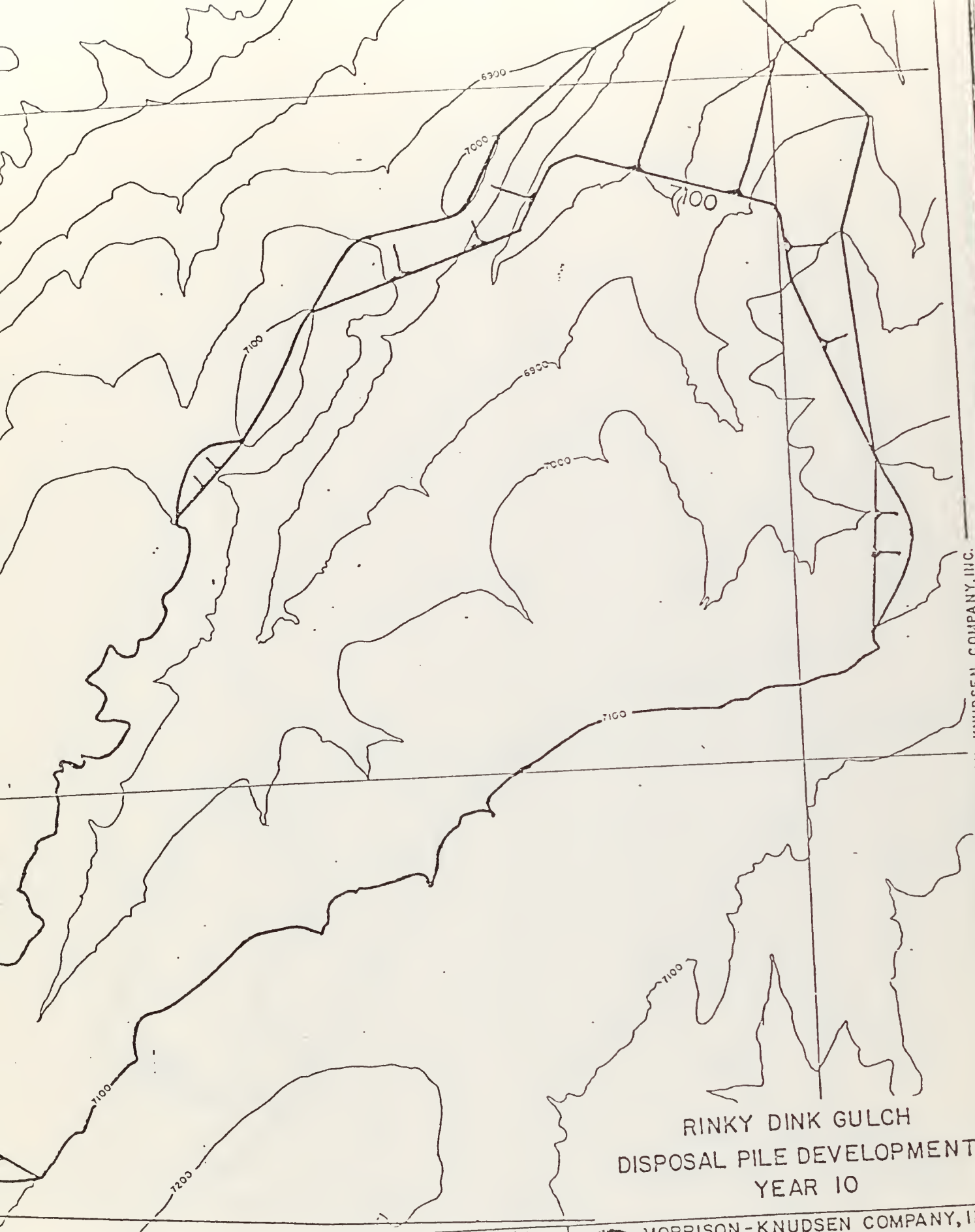
MORRISON-KNUDSEN COMPANY, INC.

NO.	BY	DRAWN BY	APPROVED BY
		J. C.	3/10/77
		CHECKED BY	SCALE
		M.M.	NTS
		CONTRACT NUMBER	
		1077	
		SHEET NUMBER	
		Figure 2-14	

MORRISON-KNUDSEN COMPANY, INC.

M.I.S. DEVELOPMENT
OF TRACT C-a

TWO MORRISON-KNUDSEN PLAZA/PO. BOX 7808/BOISE, ID. 83729



RINKY DINK GULCH
DISPOSAL PILE DEVELOPMENT
YEAR 10

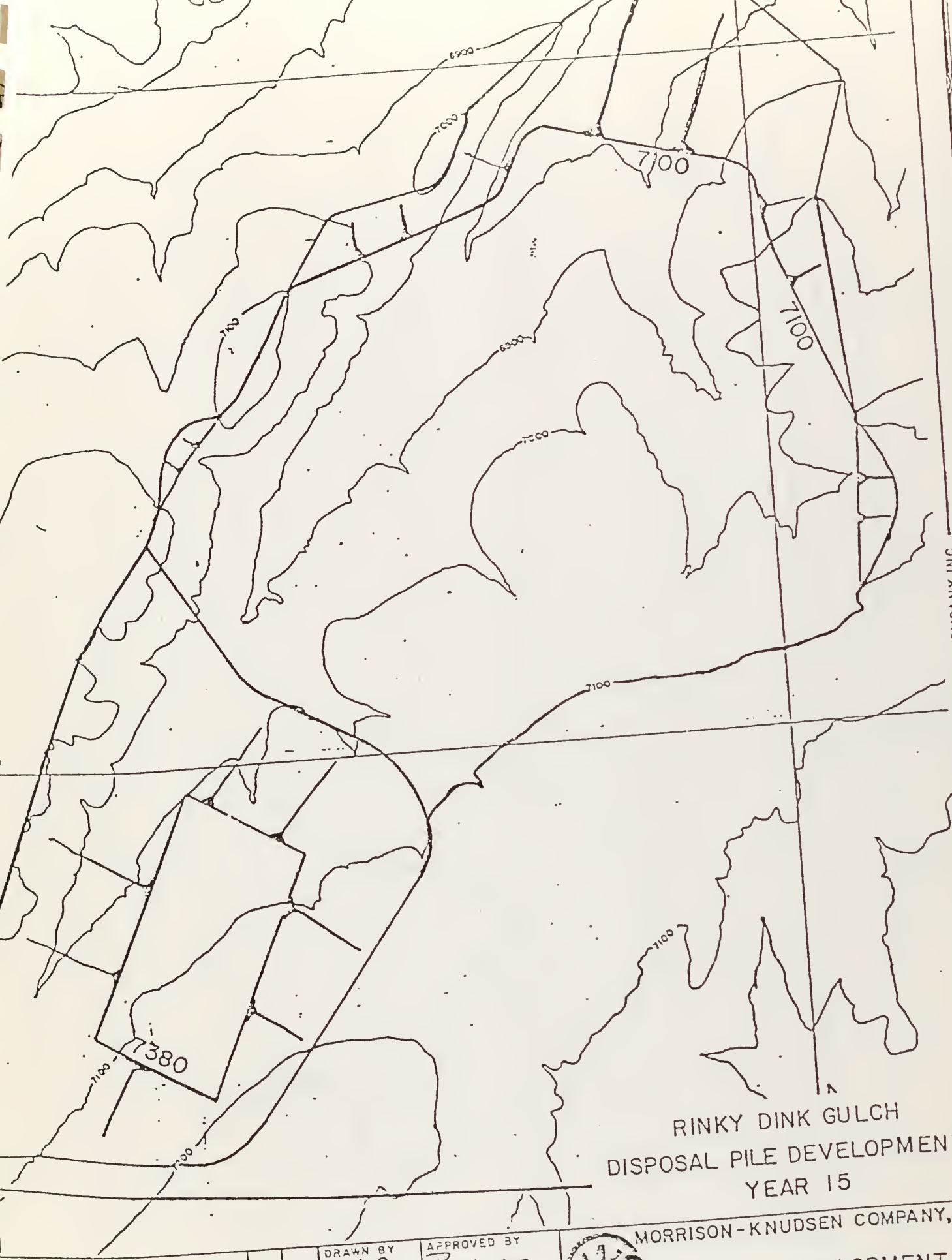
MORRISON-KNUDSEN COMPANY, INC.

DRAWN BY J.C.	APPROVED BY
CHECKED BY M.M.	SCALE NTS
CONTRACT NUMBER 1077	
SHEET NUMBER Figure 2-15	

MORRISON-KNUDSEN COMPANY, INC.

M.I.S. DEVELOPMENT
OF TRACT C-a

TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, ID 83729



RINKY DINK GULCH
DISPOSAL PILE DEVELOPMENT
YEAR 15

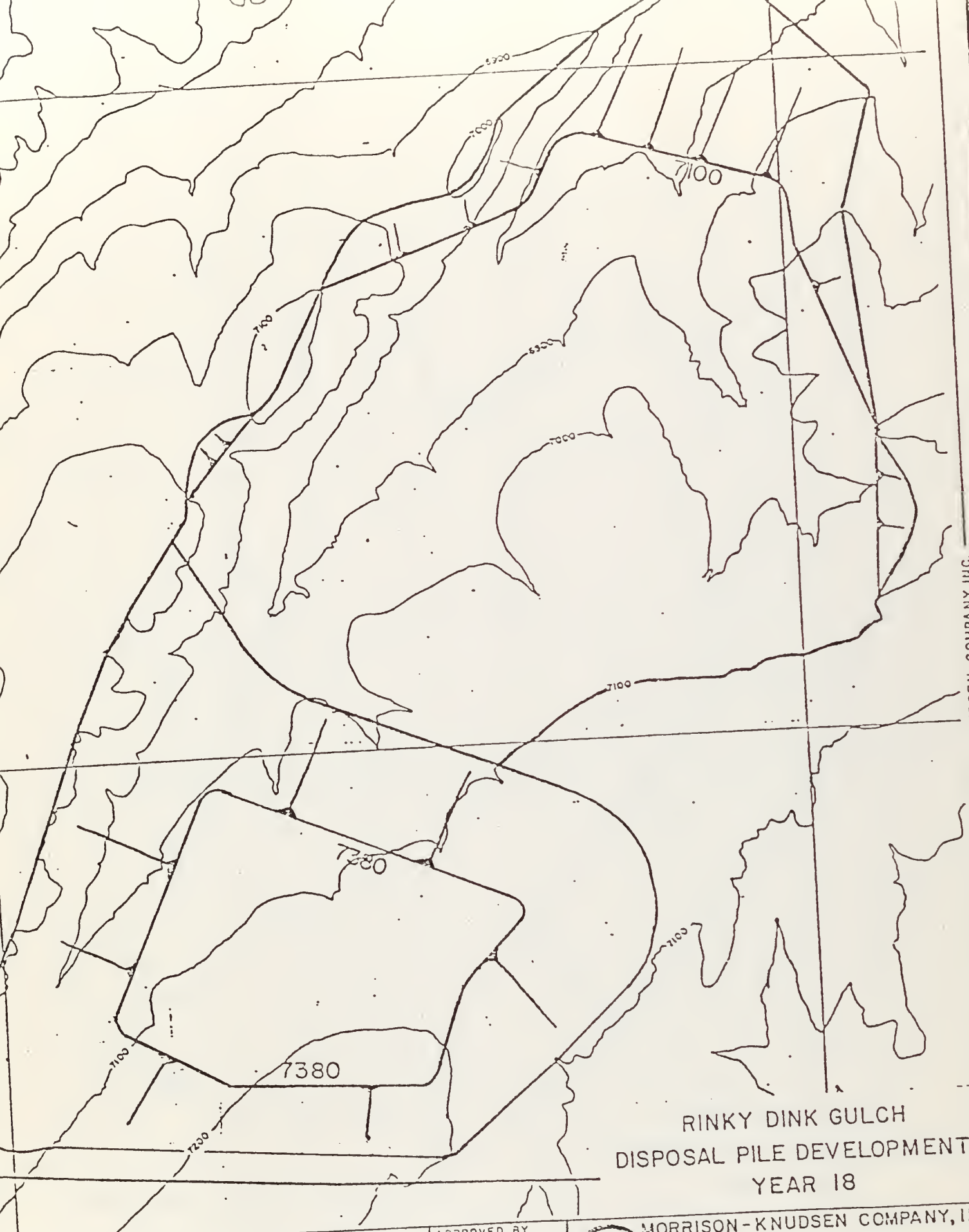
MORRISON-KNUDSEN COMPANY, INC.

DRAWN BY J.C.	APPROVED BY 3/10/77
CHECKED BY M.M.	SCALE NTS
CONTRACT NUMBER 1077	
SHEET NUMBER Figure 2-16	

MORRISON-KNUDSEN COMPANY, INC.

M.I.S. DEVELOPMENT
OF TRACT C-a

TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, ID. 83729



RINKY DINK GULCH
DISPOSAL PILE DEVELOPMENT
YEAR 18

MORRISON-KNUDSEN COMPANY, INC.

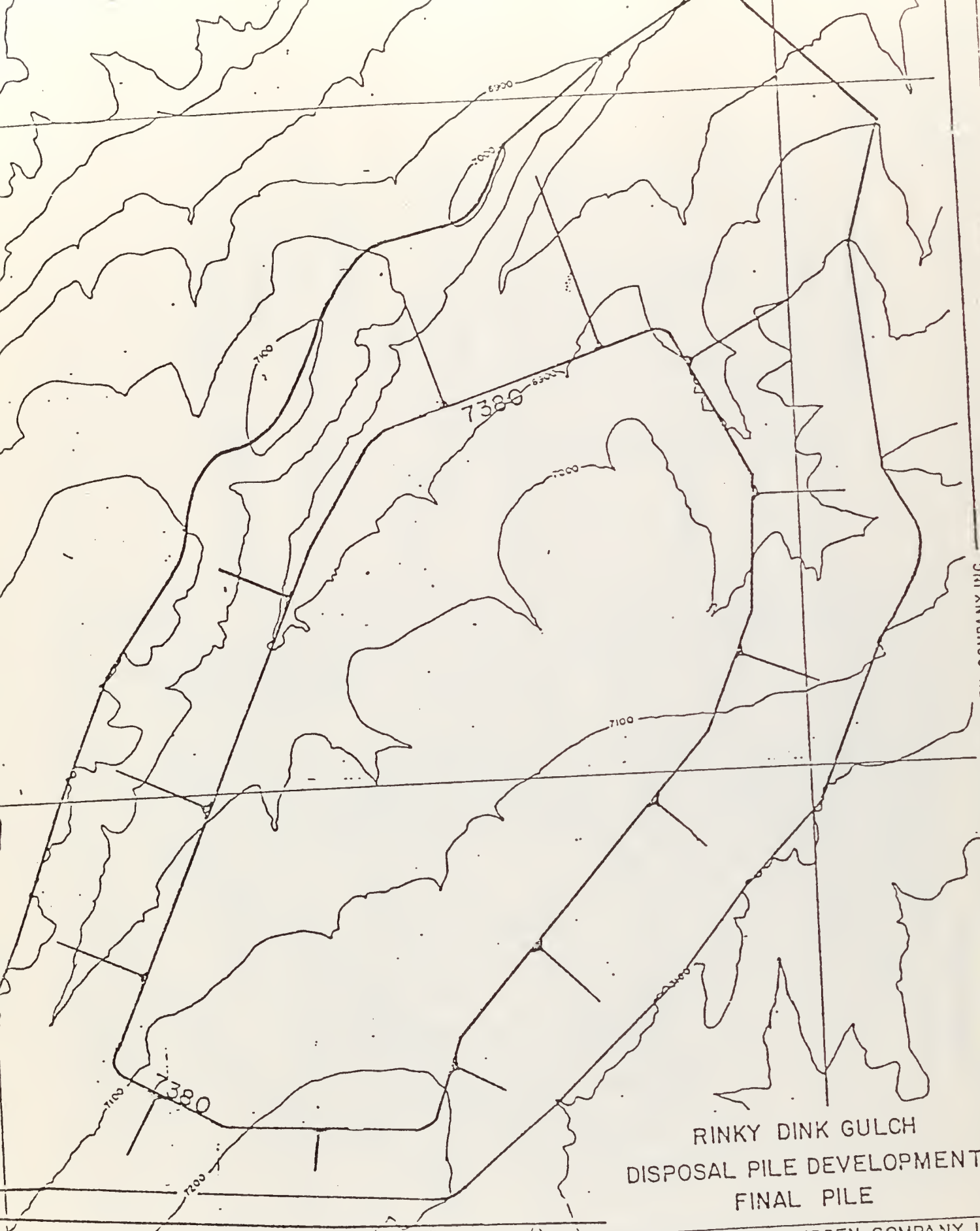
DRAWN BY J.C.	APPROVED BY D. Holz
CHECKED BY M.M.	SCALE NTS
CONTRACT NUMBER 1077	
SHEET NUMBER Figure 2-17	

MORRISON-KNUDSEN COMPANY, INC.

M.I.S. DEVELOPMENT
OF TRACT C-a

TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, ID. 83729

MORRISON-KNUDSEN COMPANY, INC.



RINKY DINK GULCH
DISPOSAL PILE DEVELOPMENT
FINAL PILE

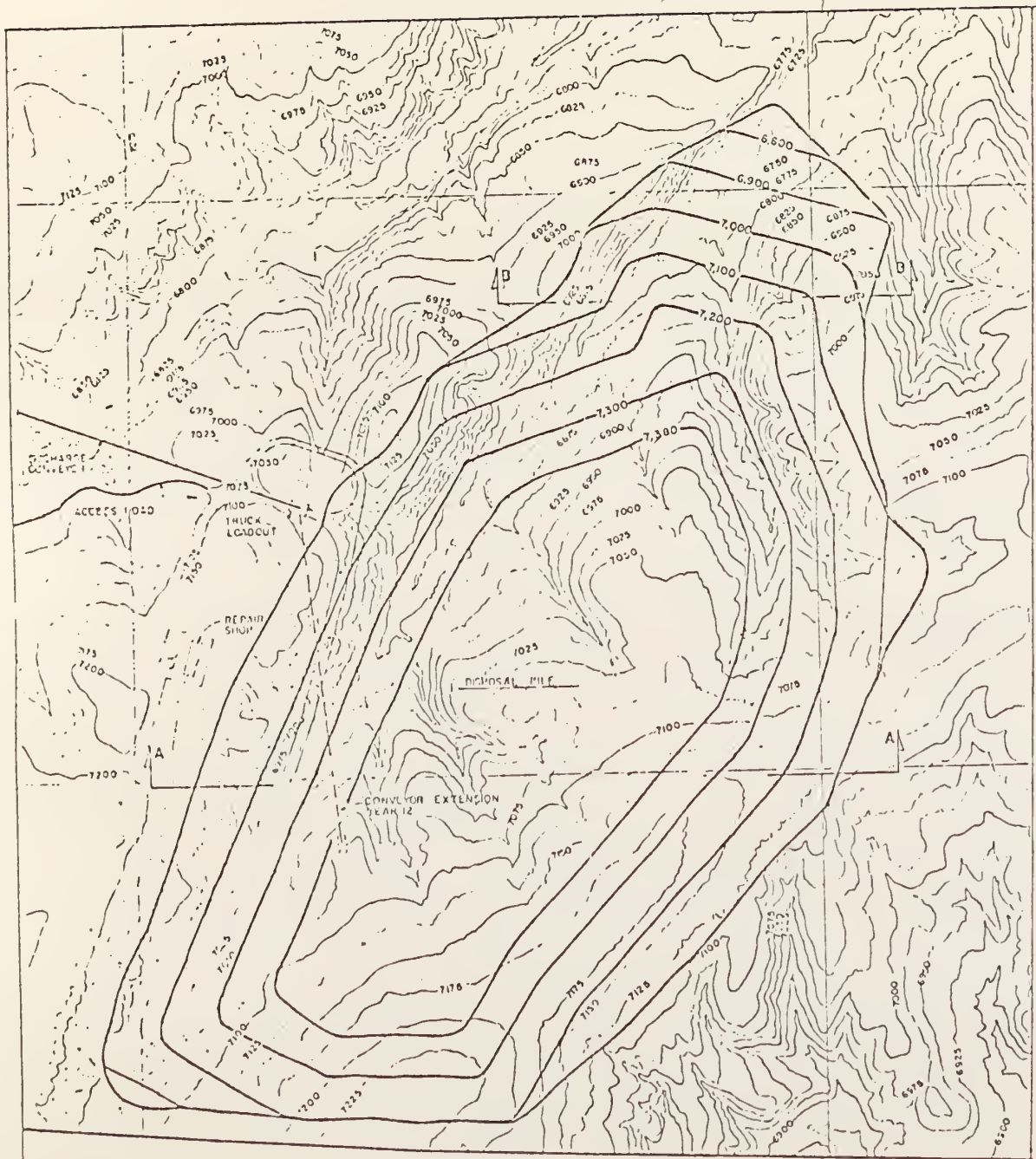
MORRISON-KNUDSEN COMPANY, INC.

DRAWN BY J.C.	APPROVED BY
CHECKED BY M.M.	SCALE NTS
CONTRACT NUMBER 1077	
SHEET NUMBER	

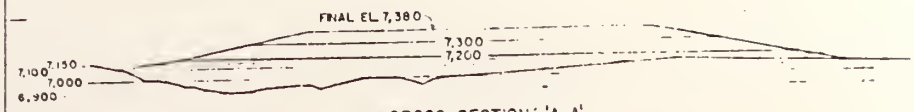
MORRISON-KNUDSEN COMPANY, INC.

M.I.S. DEVELOPMENT
OF TRACT C-a

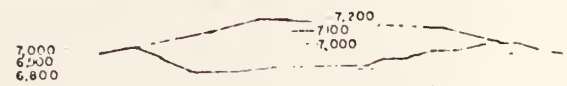
MORRISON-KNUDSEN PLAZA/P.O. BOX 7808/BOISE, ID. 83729



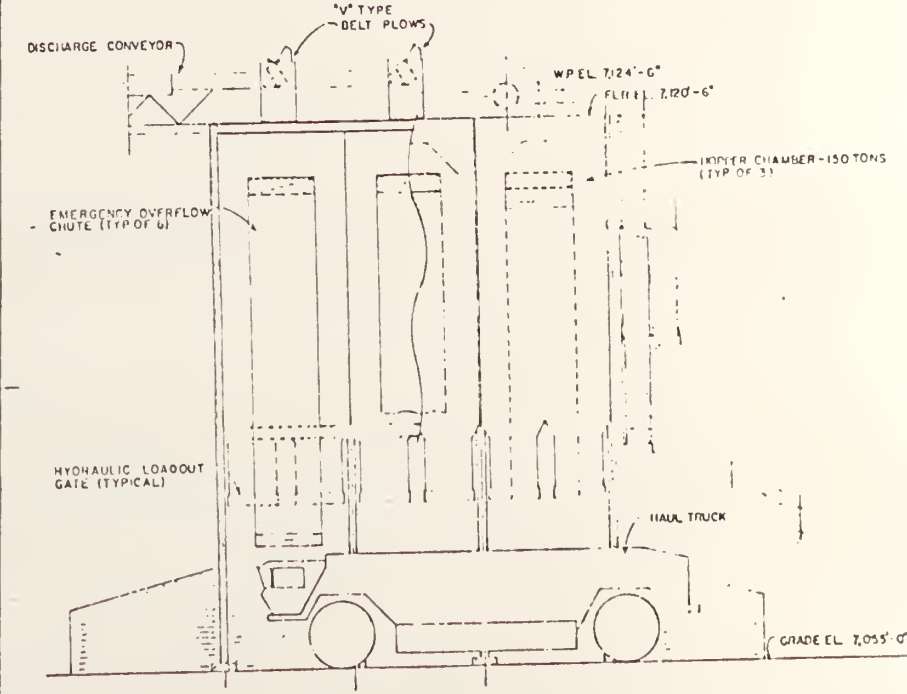
DISPOSAL PILE PLAN



CROSS SECTION 'A-A'



CROSS SECTION 'B-B'



TRUCK LOADOUT (ELEVATION)

MORRISON-KNUDSEN COMPANY

M-K'S DEVELOPMENT OF THAT FINAL PROCESSED SHALE DISPOSAL PILE AND TRUCK LOADOUT

J TIBEL		1077
JCRON	NOTED	Figure 2

04-53-5-004

TRANSPORTATION (Section 5, Chapter 2)

Q. Tract C-a is presently traversed by several public roads and trails as shown on Figure 2-2-2. The various plot plans presented in the plan do not show the relationship and effect of the planned tract development on these existing roads and trails and could be interpreted to block access across Tract C-a. Discussion on page 5-2-7 leads to the same conclusion. Please furnish clarification of RBOSP's plans for providing alternate access in accord with Section 2(M) of the environmental stipulations of the oil shale lease.

A. The statement on page 5-2-7 of the DDP about a gate across County Road 24 at the eastern tract boundary does not apply to the total length of time for the tract development. After the Rangely road is constructed, County Road 24 will bypass C-a along the north side. In that case, County Road 24 will not be blocked off even temporarily, only the access to C-a from the east would be blocked. The following plus the attached sketches should clarify what is contemplated as access during various time periods:

1977 through 1981 (see Sketch 1) - Major area of development and major access road is shown. A slight relocation of "Airplane Ridge Road" around the southern edge of the development will be required as shown on the sketch.

1982-84 (see Sketch 2) construction for expanded operations is underway during this period. A new access road on the west side of the tract from the Rangely road will be constructed. Connections from this access road will be provided to Dry Fork Road, Corral Gulch and other major tracts that are intersected. A new connection will be provided to Airplane Ridge Road to provide access to the west.

1985-86 (see Sketch 3) Areas of operation are expanded as shown but access is not affected.

1987-91 (see Sketch 4) Surface areas of operation are expanded as shown and underground operation will be underway in the cross-hatched area. Access above the underground operations will be restricted but access to the areas to the east and west of this area is available. Access to trails to the south of the tract is available over existing trails from Stake Springs Draw.

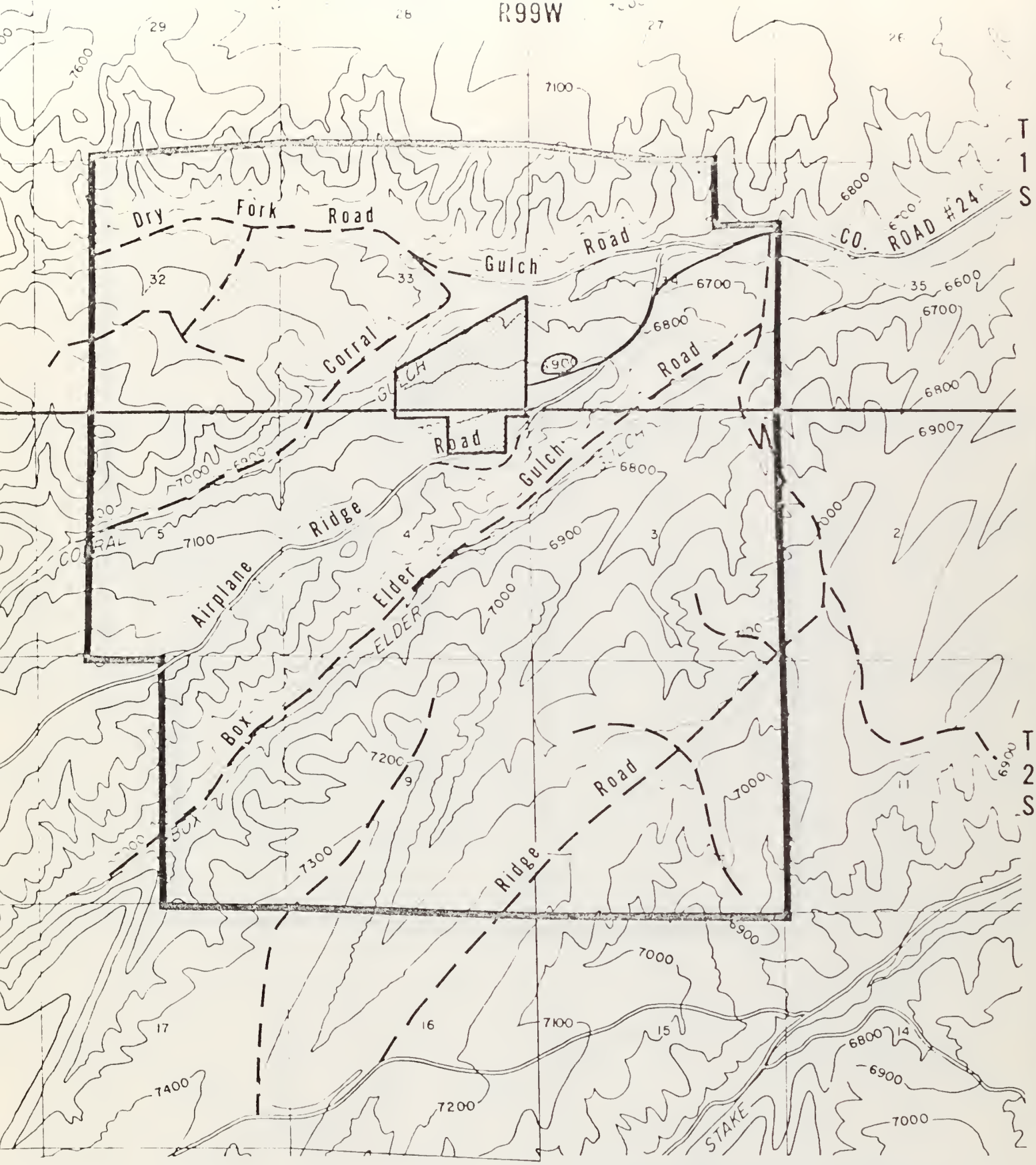
1991-97 (see Sketch 5) Underground operations have moved to a new area shown cross-hatched on the sketch and access to this area will be restricted. At this time, a gate across County Road 24 (access road to Tract C-a) will be installed at the east tract limit. Access to the cross-hatched area shown on Sketch 4 will be opened from the west. To provide access to Box Elder Gulch Road, a new trail will be provided to connect to Ridge Road at the southwest corner of Tract C-a as shown on Sketch 5. Access to Ridge Road west of the tract is available over existing trails from Stake Springs Draw.

1997-2008 (see Sketch 6) Underground operations have moved to a new area shown cross-hatched on the sketch and access to this area will be restricted. Access to the cross-hatched area shown on Sketch 5 will be opened and the gate across County Road 24 will be removed. All other access remains the same.

2008-2016 (see Sketch 7) Underground operations have moved to a new area shown cross-hatched on the sketch and access to this area will be restricted. Access to the area shown cross-hatched on Sketch 6 will be opened. All other access remains the same.

The above times indicated are approximate and may vary slightly.

Service and haulage roads on-tract will have crushed rock surfacing. Internal service roads will not require road bed widths greater than 50 feet in accordance with the lease stipulations. Should design and safety considerations require haulage road bed widths greater than 50 feet, prior approval will be obtained from the AOSS.



LEGEND

- TRACT OUTLINE
- ROADS
- UNDERGROUND RETORTS
- SURFACE DEVELOPMENT

0 3000 6000

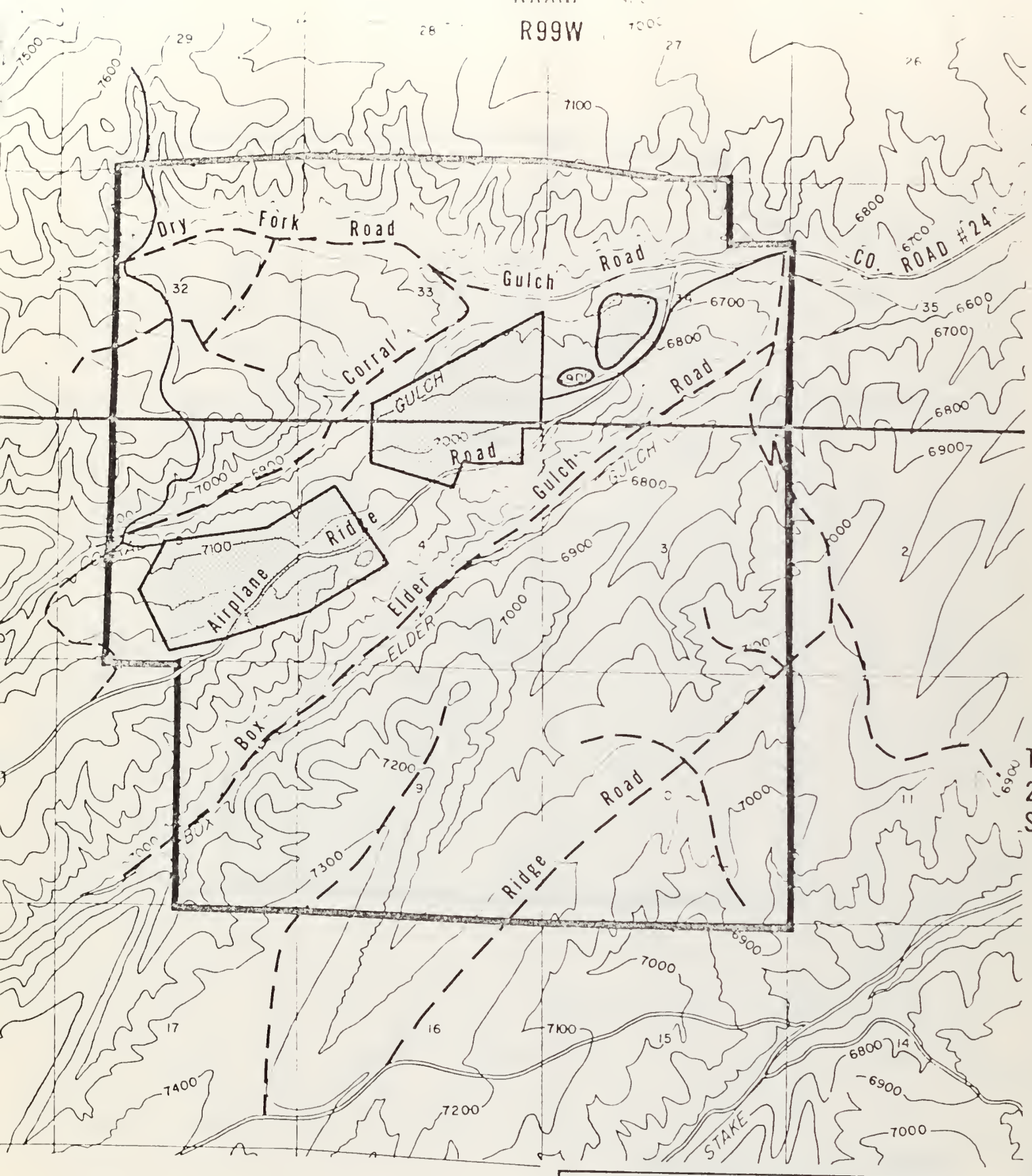
FEET

RIO BLANCO OIL SHALE PROJECT

RIO BLANCO COUNTY, COLORADO

TRACT C-a ROAD ACCESS DURING DEVELOPMENT 1977-1981

DRAWN BY		SCALE 1"=3000'	FIGURE
DESIGN BY HGK		DATE 7-77	
APPROVED BY		DRAWING NO 1 of 7	



LEGEND

- TRACT OUTLINE
- ROADS
- UNDERGROUND RETORTS
- SURFACE DEVELOPMENT

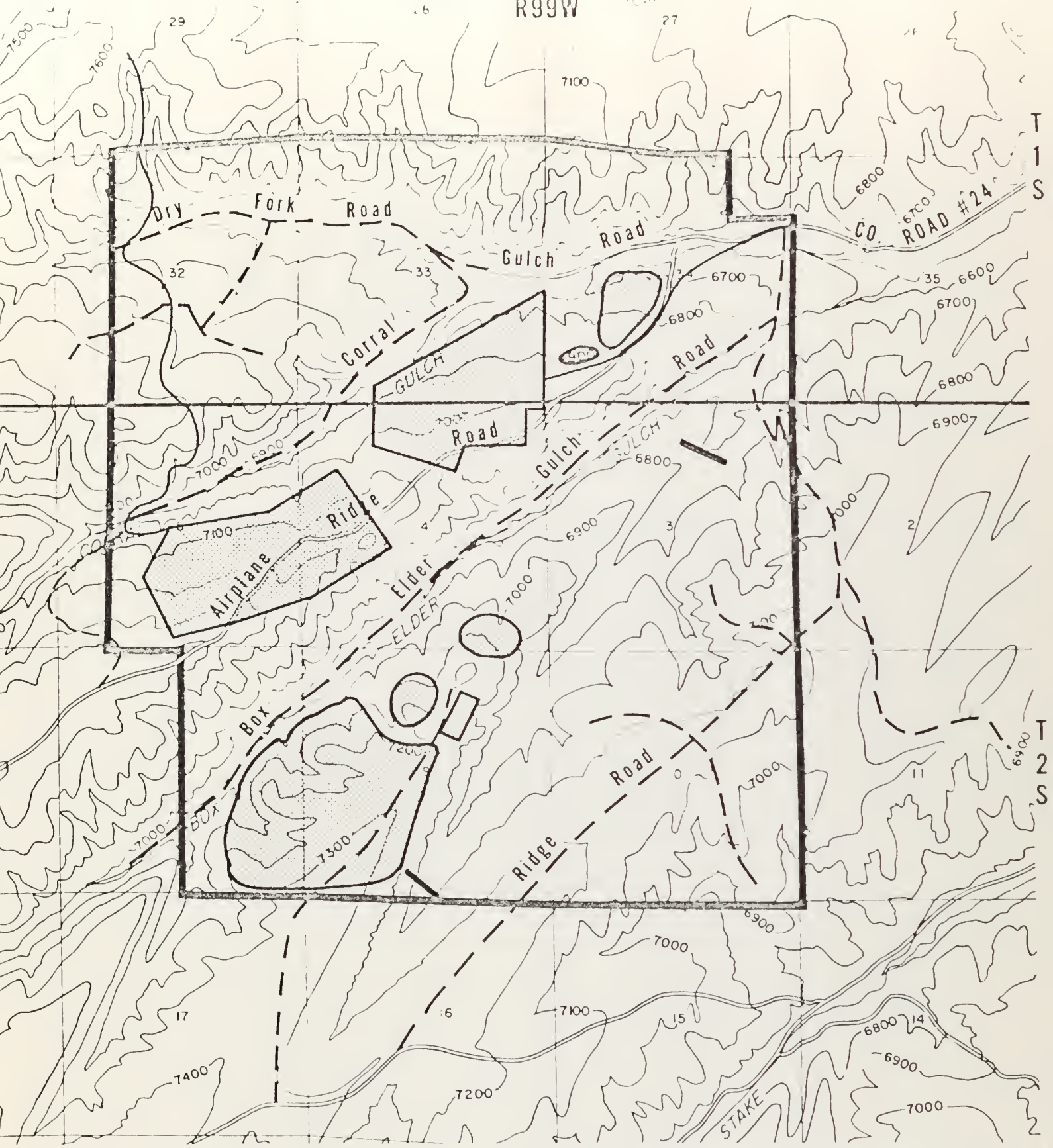
0 3000 6000
FEET

RIO BLANCO OIL SHALE PROJECT

RIO BLANCO COUNTY, COLORADO

TRACT C-a ROAD ACCESS DURING DEVELOPMENT 1982-1984

DRAWN BY:		SCALE:	1"=3000'
DESIGN BY:	HGK	DATE:	7-77
APPROVED BY:		DRAWING:	2 of 7



LEGEND

TRACT OUTLINE

ROADS

UNDERGROUND RETORTS

SURFACE DEVELOPMENT

0 3000 6000

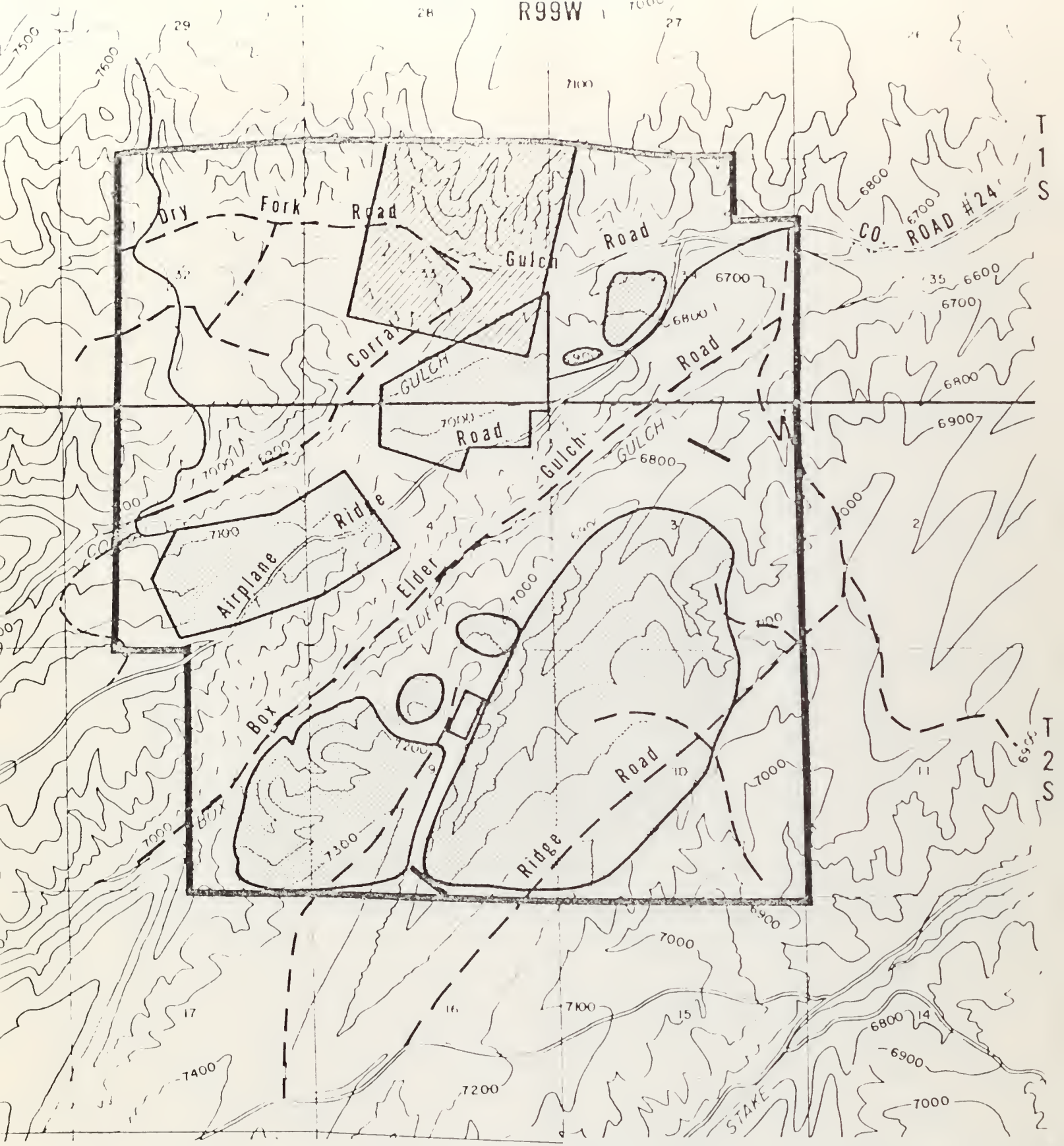
FEET

RIO BLANCO OIL SHALE PROJECT

RIO BLANCO COUNTY, COLORADO

TRACT C-a ROAD ACCESS DURING DEVELOPMENT 1985-1986

DRAWN BY		SCALE 1"=3000'	FIGURE
DESIGN BY HGK		DATE 7-77	
APPROVED BY		DRAWING NO 3 of 7	



LEGEND

TRACT OUTLINE

ROADS

UNDERGROUND RETORTS

SURFACE DEVELOPMENT

0 3000 6000

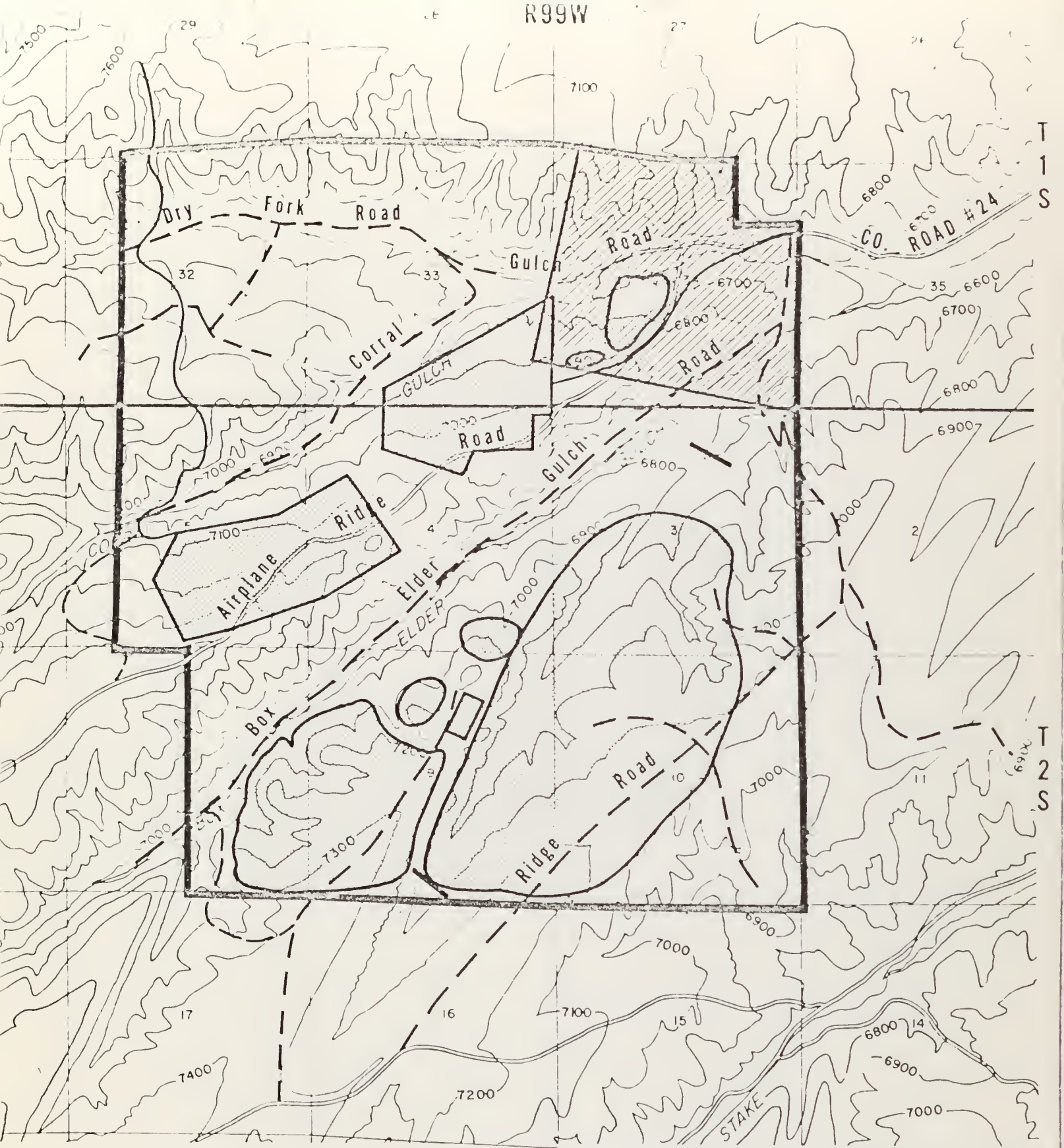
FEET

RIO BLANCO OIL SHALE PROJECT

RIO BLANCO COUNTY, COLORADO

TRACT C-a ROAD ACCESS DURING DEVELOPMENT 1987-1991

DRAWN BY	SCALE 1"=3000'	FIGURE
DESIGN BY HGK	DATE 7-77	
APPROVED BY	DRAWING NO. 4 of 7	



LEGEND

TRACT OUTLINE

ROADS

UNDERGROUND RETORTS

SURFACE DEVELOPMENT

0 3000 6000

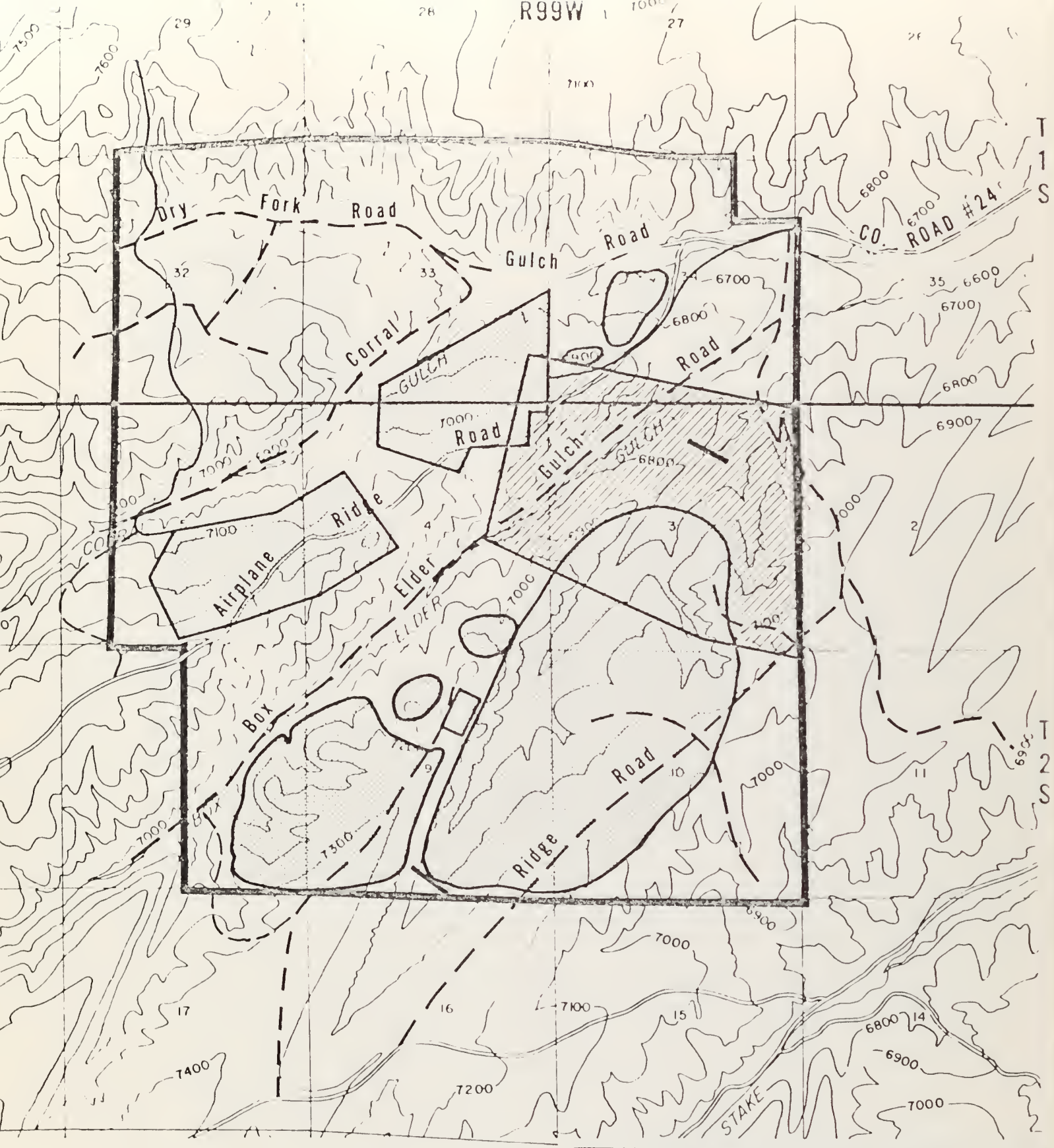
FEET

RIO BLANCO OIL SHALE PROJECT

RIO BLANCO COUNTY, COLORADO

TRACT C-a ROAD ACCESS DURING DEVELOPMENT 1991-1997

DRAWN BY		SCALE 1"=3000'	FIGURE
DESIGN BY HGK		DATE 7-77	
APPROVED BY		DRAWING 5 of 7	



LEGEND

TRACT OUTLINE

ROADS

UNDERGROUND RETORTS

SURFACE DEVELOPMENT

0 3000 6000

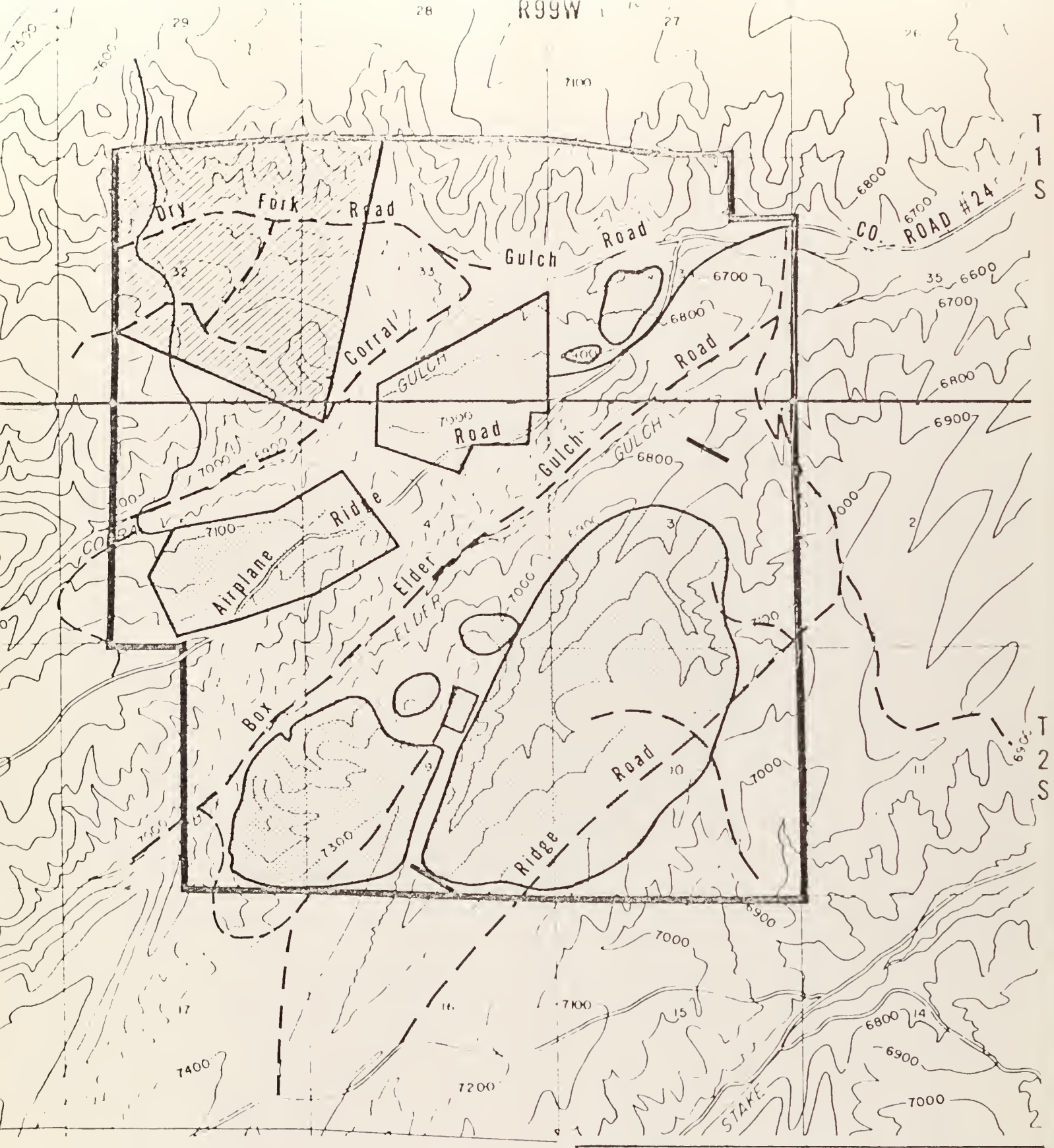
FEET

RIO BLANCO OIL SHALE PROJECT

RIO BLANCO COUNTY, COLORADO

TRACT C-a ROAD ACCESS DURING DEVELOPMENT 1997-2008

DRAWN BY	SCALE 1"=3000'	FIGURE
DESIGN BY HGK	DATE 7-77	
APPROVED BY	DRAWING NO. 6 of 7	



LEGEND

TRACT OUTLINE

ROADS

UNDERGROUND RETORTS

SURFACE DEVELOPMENT

0 3000 6000

FEET

RIO BLANCO OIL SHALE PROJECT

RIO BLANCO COUNTY, COLORADO

TRACT C-a ROAD ACCESS DURING DEVELOPMENT 2008-2016

DRAWN BY	SCALE 1"=3000'	FIGURE
DESIGN BY HGK	DATE 7-77	
APPROVED BY	DRAWING NO. 7 of 7	

AIR QUALITY CONTROL (Section 6, Chapter 5)

Q. A table of all pollutants, including footnotes explaining the basis of estimation, was requested in a meeting with OSEAP members on June 13, 1977, and mentioned in Mr. Berry's letter of June 19, 1977. This information is requested in order to expedite our review of this area of the Revised DDP.

A. The tables follow:

MDP EMISSIONS
lb/hr

	SO_2	NO_x	Particulates	Hydrocarbons	CO
Steam boiler	62[1]	62[2]	33[4]	5.2[4]	—
Incinerator	371[1]	831[2]	42[4]	2.3[4]	—
Tank vapor losses	—	—	—	2.4[6]	—
Mine ventilation	—	26[3]	1.6[3]	—	33[3]
ROM Development Ore Disposal	—	—	14.3[5]	—	—
	433	919	90.9	9.9	33

[1] Assumes total conversion of sulfur in fuel to SO_2.

[2] Calculated by Foster Wheeler based on gas composition, flame temperature, size of flame envelope.

[3] Based on Colorado Mining Regulations

[4] Based on AP-42.

[5] Based on AP-42 where possible, other information used as necessary.

[6] Based on AP-42, Supplement No. 1, July 1973.

COMMERCIAL PHASE EMISSIONS

lb/hr

	SO_2	NO_x	Particulates	Hydrocarbons	CO
Tosco preheat	42[1]	429[2]	120[9]	147[7]	–
Tosco steam superheater	0.6[1]	21[2]	21[4]	–	–
Tosco shale Moisturizing	–	–	30[4]	–	–
High BTU gas plant	0.3[1]	8[2]	0.3[5]	0.6[11]	–
Thermal Oxidizer	31[1]	50[2]	0.7[5]	0.7[11]	–
Power generation	384[1]	1860[2]	320[8]	20[11]	–
Tank vapor losses	–	–	–	6[10]	–
Mine ventilation	–	530[3]	31[3]	–	658[3]
Feedstock preparation and materials handling	–	–	42[6]	–	–
Processed shale deposit	–	–	11[6]	–	–
Total	457.9	2898	576	174.3	658

[1] Assumes total conversion of sulfur in fuel to SO_2.

[2] Calculated by Foster Wheeler using gas composition, flame temperature, size of flame envelope.

[3] Based on Colorado Mining Regulations

[4] Based on information received from scrubber vendors.

[5] Based on AP-42.

[6] Based on AP-42 where possible, other information used as necessary.

[7] Based on Tosco information.

[8] United Technologies Bulletin, "Turbo Power Tech Talk", No. 4, Emissions Control.

[9] Based on information from scrubber vendors. Includes approximately 60#/hr hydrocarbons.

[10] Based on AP-42, Supplement No. 1, July 1973.

[11] Foster Wheeler Estimate

ESTIMATES OF SULFUR CONTENT
OF
MODIFIED IN SITU OFF-GAS

47,000 BPSD liquid oil from MIS retorts
C-a Detailed Development Plan

	MIS Retort Off-gas 1.4 x 10^9 SCFD			MIS Stack Gas 3 x 10^9 SCFD		
	Available Data[1] (not C-a Shale)		Selected for C-a	C-a		
	Minimum ppm	Maximum ppm	DDP ppm	DDP Design % Removal	SO_2 in stack gas ppm	SO_2 in stack gas lbs/hr
H_2S	50	3500	2000	99.5	4	91
COS	0	200	200	90.1	8	172
SO_2	0	5	3	0	2	30
Sulfur in hydrocarbons	-	-	150[2]	93.8[3]	4	91
					18	384

(1) Reported measurements of sulfur compounds, ppm

	LLL	LERC	OXY
H_2S	1500-3500	50-200	2000
COS	detected but not quantified yet	0-200	0
SO_2	below detection limit of 10 ppm	0-5	0

(2) Includes mercaptans, oil mist (l) and oil vapors (g) based on data from surface retorts.

(3) Removal of 93.8 percent of hydrocarbons increases oil recovery by 10,000 BPSD for a total of 57,000 BPSD.

KLB/jr
5/24/77

RIO BLANCO OIL SHALE PROJECT
PROCESSING EMISSIONS OF SO_2 IN LBS/HR

	Modular Development Phase		Commercial Phase	
	Open Pit DDP (Phase 2, Stage 2)	MIS DDP (Retorts 6 & up)	Open Pit DDP (55,800 BPSD)	MIS DDP (76,000 BPSD)
TOSCO II				
Preheat System	15.2	-	217	42
Steam Supht. Ball Circ.	2.8	-	33	0.6
GCR				
Air Preheater	-	-	1.4	-
Coker Feed Heater	-	-	1.0	-
Coke Cooler Vent to Flare	-	-	3	-
Gas Oil HT Heater	-	-	1.9	-
Gas Oil HT Fired Reboiler	-	-	1.8	-
Naphtha HT Heater	-	-	0.5	-
Hydrogen Plant CO_2	-	-	12	-
Glycol Fired Reboiler	-	-	1.6	-
Sulfur Plant Tailgas	-	-	40	-
Utility Boilers	-	62	6.6	-
Thermal Cracker Preheat	2.2	-	-	-
High BTU Gas Plt. Reboiler	0.4	-	-	0.3
Steam Superheater	1.4	-	-	-
Thermal Oxidizer	5.2	371	-	31
Power Generation Plt.	-	-	-	384
Total	27.2	433	319.8	457.9

KLB/jr
5/24/77

COMPARISON OF MODELING RESULTS WITH APPLICABLE INCREMENTS

	Allowable Increments		Maximum Predicted Off-site Increments			
	State Cat. I	State Cat. II Federal Class II	March, 1976 Open Pit DDP, Tract C-a		May, 1977 MIS DDP, Tract C-a	
			Modular	Commercial	Modular	Commercial
SO_2 ug/m^3						
Annual	3	15	1	2	3.2	2.7
24-hour	15	100	14	19	5	3
3-hour	75	700	82	94	30	20
Particulates, ug/m^3		Federal Class II				
Annual		10	4	10	0.3	3
24-hour		30	22	29	1.0	3

KLB/jr
5/24/77

COMPARISION OF MODELING RESULTS WITH APPLICABLE ABSOLUTE STANDARDS

(Plant Increment plus background)

	National Ambient Air Quality Standards		State Standard	MAXIMUM PREDICTED OFF-SITE VALUE			
				Open Pit DDP Tract C-a		MIS DDP Tract C-a	
SO_2, ug/m^3	Primary	Secondary		Modular	Commercial	Modular	Commercial
Annual	80	-	-	6	7	8.4	8
24-hour	365	-	-	19	24	10.2	8
3-hour	-	1,300	-	87	99	35.2	25
Particulates, ug/m^3							
Annual	75	60	45	20	19	9	12
24-hour	260	150	150	38	38	10	12
NO_2, ug/m^3							
Annual	100	-	-	16	10	8	13
NMHC, ug/m^3							
3-hour (6-9 AM)	160	-	-	221	129	65	90

KLB/jr
5/24/77

WATER QUALITY CONTROL (Section 6, Chapter 6)

Q. Page 1-6-15. A tabular listing of the sizes, approximate locations, whether or not they will be lined, and type of lining material for the retention ponds, blow-down surge ponds, evaporation fields, the Rinky Dink Gulch impoundment and any other water impoundments would be helpful.

A. Please refer to Figure 1-3-3, Page 1-3-9 and Figures 1-6-1 and 1-6-2 on Pages 1-6-15 and 16. The rectangle with rounded corners shown in Figures 1-6-1 and 2 indicate the various ponds and reservoirs and their locations are shown in Figure 1-3-3. These facilities have been tentatively sized but final sizing will depend on final detail design.

Water impoundment	Capacity AF	Lining
Mine Service Area Rentention Pond	70	Yes
Blowdown Surge Pond	60	Yes
Plant Site Retention Pond	158	Yes
Rinky Dink Gulch Reservoir	900	Yes
Rinky Dink Diversion Dam	347	No

Rinky Dink Diversion Dam is shown but not named on Figure 1-3-3 but is located near the tract boundary at the south end of the processed shale disposal pile. This dam is not shown on Figures 6-2-2 and 6-6-3 because it does not enter into the water supply and usage.

The evaporation field is an emergency disposal area for evaporating excess water. It has an area of about 10 acres. It will be lined and will have collection ditches and dikes to return any runoff back to the surge pond.

The type of linings have not yet been determined. It is our plan to use local soils when feasible to line the impoundments. If tests indicate that these soils are not adequate, the addition of bentonite will be investigated. Other linings to be considered are polymers, sheet-type linings, asphalt and concrete in approximately that order.

Page 6-6-8 of the Revised DDP lists the design basis for surface runoff, diversion and retention facilities.

MODULAR DEVELOPMENT AND COMMERCIAL PHASE WATER BALANCES (Section 6, Chapter 6)

Q. Page 6-6-1. Because there are some apparent inconsistencies of the amounts of water expected to be encountered from mine dewatering and mine seepage, as well as the amount of water to be used in both the MDP and CDP, it would be helpful to summarize the water balance by placing quantitative figures on Figure 6-6-2 for the MDP and Figure 6-6-3 for the CDP. This should clarify the water balance.

A. The attached Figures 6-6-2 and 6-6-3 from the DDP have been marked with the average flows (gpm) that are expected during the MDP and CDP. A line from the Mine Service Area Retention Pond to the Process was inadvertently omitted and has been added to Figure 6-6-2.

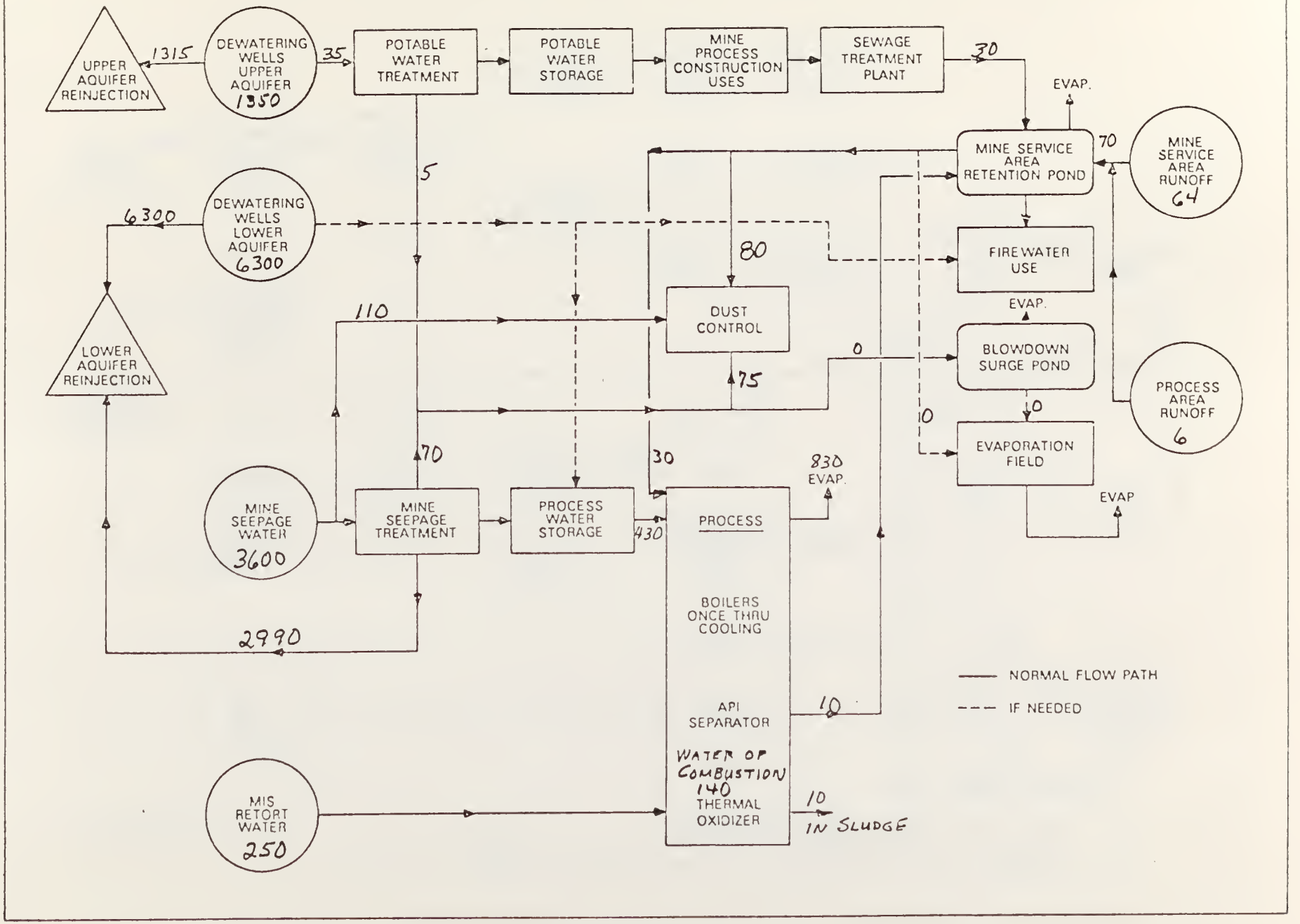


FIGURE 6-6-2

WATER FLOW - MODULAR DEVELOPMENT PHASE - GPM

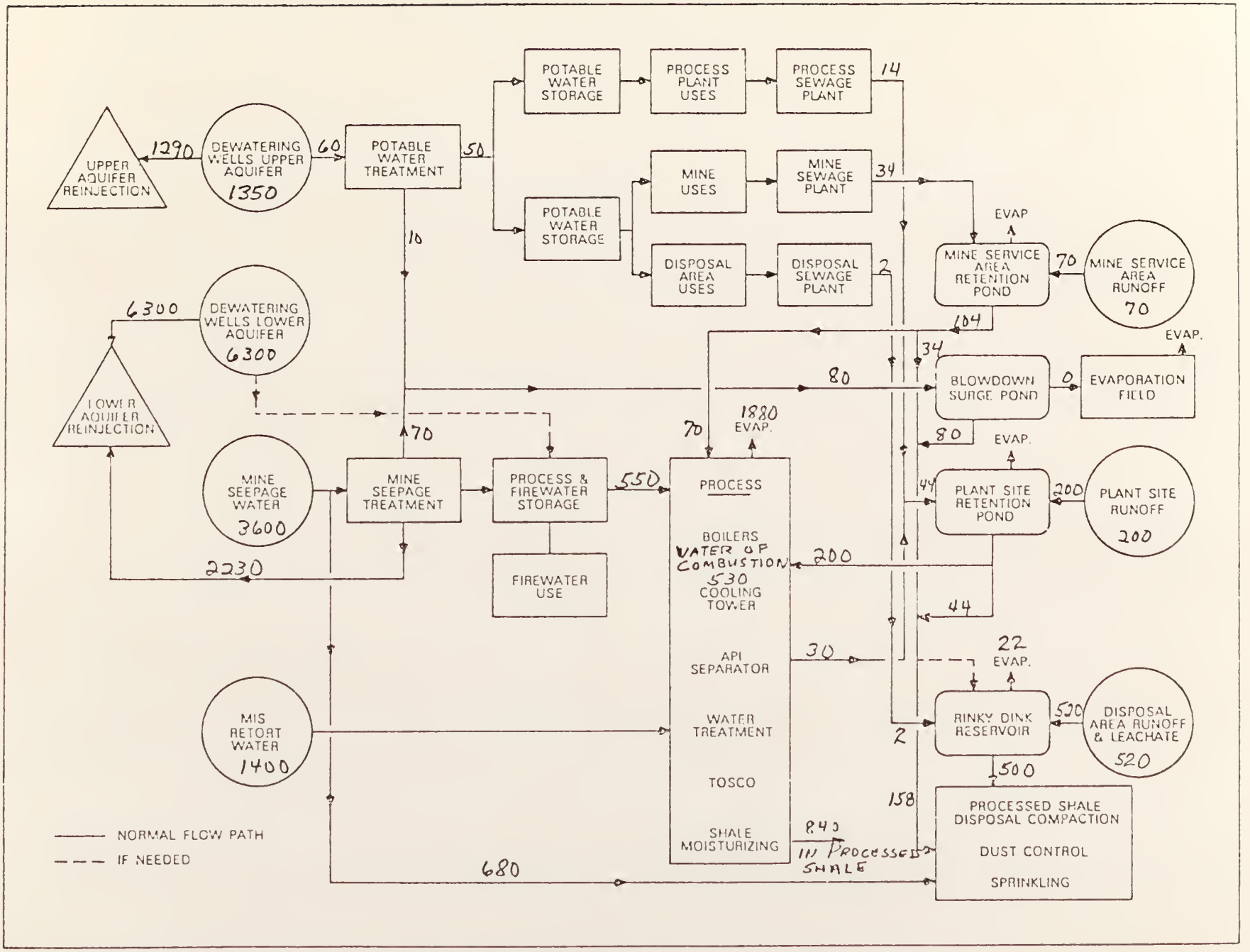


FIGURE 6-6-3

WATER FLOW - COMMERCIAL PHASE - GPM

EFFECT OF UNDERGROUND RETORTS ON GROUNDWATER (Section 6, Chapter 14) .

Q. Effect of underground retorts on groundwater.

This subject is ignored in the Revised DDP but presumably could be considered in the light of experimental information made available to the lessee by the Lawrence Livermore Laboratory and the Laramie Energy Research Center. This information probably includes data on the physical, chemical, and mineralogical properties of material left in underground retorts. These properties in turn, coupled with knowledge of groundwater factors, might provide a basis for predicting the effect of underground retorts on ground water. The probable errors in such a prediction would surely be considerable, but an attempt at forecasting the effect on groundwater should be made. Fortunately, the lessee plans to approach commercial production through work with smaller retorts during a Modular Development Phase, and water quality of oil shale aquifers would be monitored from the start of operations (p. 8-6-16). Such monitoring would provide the opportunity to measure possible chemical changes resulting from contact of ground water with underground retorts, besides merely the planned measurements of conductivity and temperature. In summary, (1) experimental evidence should be applied in forecasting the probable effect of underground retorts on groundwater, and (2) the forecast should be evaluated by the results of monitoring during the Modular Development Phase.

A. We had been hopeful that predictions of the effects of in situ operations on groundwater quality could be made, and asked Lawrence Livermore Laboratories if they could supply us with information. They concluded that they did not have sufficient information to make a significant statement.

Laramie Energy Research Center has produced a number of studies of water quality from in situ burns at Rock Springs, Wyoming and from in situ simulations at Laramie. These have focused on analyses of the retort waters rather than on obtaining the kind of information needed to study the effects of an abandoned retort on groundwater quality.

We feel that the best solution to potential groundwater leaching problems is to render spent retorts impermeable through slurry backfilling with surface retorted shale. Research and development of this technique will be carried out during the Modular Development Phase. A program presently under consideration to accomplish this is attached. This program is subject to change as the work progresses. We are hopeful of coordinating efforts with government agencies so as to maximize the results from both government and industry efforts.

In the meantime we intend to monitor groundwater quality during the MDP. The lack of data coupled with uncertainties regarding the burn temperature which could effect the solubility of the residual shale and the rate of inflow of groundwater into the retorts, leads us to believe that it would serve little purpose to predict effects at this time. A scope of work for the groundwater monitoring will be submitted to the Area Oil Shale Office prior to commencement of operations. We believe that this detailed monitoring plan coupled with the research program will suffice to evaluate any effects due to groundwater leaching of materials from the commercial underground retorts.

MODULAR DEVELOPMENT PHASE
RESEARCH PROPOSAL FOR MODIFIED IN SITU RETORT INTEGRITY

A four-step sequential research project is proposed to conduct the structural and seepage tests in burned and slurry grouted spent shale rubble that are needed to develop the engineering criteria required to design safe and economical, commercial in situ retorts for the recovery of oil from Colorado shale. The first three steps of the program investigate the subsidence induced in the ground by retorting during the Modular Development Phase, the effects on stability of slurry grouting spent retort rubble and post retorting groundwater permeability and leaching conditions in relation to containment of hydrocarbon contaminated seepage. Criteria from these three steps are then used to predict the structural integrity of the five Modular Development Phase retorts. The fourth step of our program instruments the first and last modular development retort cavities and their rubble, it measures subsidence, grouting and permeability performance parameters and correlates them with our earlier predictions. Thus, this activity demonstrates actual commercial in situ retort design conditions and residual liquids containment procedures necessary for safe underground operations.

Step I - Retort Induced Subsidence

Technical Objectives:

1. Review literature on existing ground subsidence problems from shallow and deep mining and from sink hole formations in coal and limestone deposits.
2. Conduct a large laboratory model test of shale retorted to various void ratios for volume loss and subsidence under varying overburden stresses.

3. Repeat volume loss tests with varying quantities of slurry additives or grouts injected into the spent shale voids.
4. Develop procedures to monitor the subsidence of the first and fifth Modular Development Phase retorts.

Step II - Slurry Grouting of Spent Shale Rubble

Technical Objectives:

1. Review literature on existing rubble grouting procedures to determine how to achieve the maximum penetration distance effectively through manipulation of slurry shale particle size, slurry viscosity, grouting pressure and hole injection sequence.
2. Conduct laboratory experiments to define and optimize grouting characteristics for shale rubble to minimize porosity, to utilize surface pre-wetting if needed, and to be effective under the temperature, absorption and other environmental conditions anticipated in shales retorted in situ.
3. Use a large scale laboratory rubble model, in the size range of 6 to 10 feet, to demonstrate grout penetration, stability, subsidence and permeability properties, i.e., confirm the smaller laboratory test of steps I and II.

Step III - Permeability and Leaching of Spent Shale Rubble and Slurry Grout

Technical Objectives:

1. Review all area groundwater conditions and define site underground hydraulics to establish parameters for modeling flow conditions.
2. Conduct laboratory leaching tests on freshly retorted and partially aged saturated spent shale to define immediate post retorting seepage flow problems for vapor cooled and steam and/or water quenched rubble.

3. Repeat the leaching tests with the selected slurry grout after permeability objectives have been established. Any chemical or mechanical sealant additives used to lower seepage losses to acceptable levels (such as bentonite, silica gel, AM-9, etc.) will be included in the leaching tests.
4. Use the large scale laboratory shale rubble model to check leachant quantities and qualities under in situ retort hydraulic gradients.

Step IV - Modular Development Phase Field Conformation Demonstration

Technical Objectives:

1. Define significant shale rock and retort rubble parameters including thermal conductivity, structural integrity, subsidence, permeability and seepage.
2. Model mathematically retorting effects on these parameters.
3. Instrument Modular Development Phase retorts #1 (the smallest) and #5 (the largest) with strain gages, load cells, temperature sensors, accelerometers, piezometers, leachant collectors, etc. to monitor underground conditions before, during and after retorting.
4. Check measured data with math model, modify model as required, expanding it from retort 1 and 5 performance correlations to full scale in situ commercial retort operating conditions.

HYDROLOGY IMPACT ASSESSMENT (Section 7, Chapter 6)

Q. Page 7-6-2 references hydrologic modeling studies underway to further define the reinjection and mine dewatering systems. Recent discussions with RBOSP staff indicate that reinjection wells may not now be planned at the 3½ to 5 miles from the tract boundaries as indicated in the Revised DDP. Please provide the details on the plans for dewatering and reinjection as defined by hydrologic modeling to date. Of concern are the number, location, rates of flow, etc., of both dewatering and reinjection wells during the MDP and commercial phases. Also provide a discussion of the expected aquifer effects expected from the system as shown by modeling to date.

A. We are still studying the optimum arrangement for the dewatering/ reinjection well system for the Modular Development Phase. Currently we are considering a plan of about ten dewatering wells surrounding the first five retorts and mine shafts, pumping water only from the upper aquifer. We have decided to eliminate the production shaft penetration into the lower aquifer during the MDP. Hence we will have no need to dewater the lower aquifer even for a short time.

The MDP plan will consist of a ring of dewatering wells surrounding the shafts and retorts 1 to 5 at a distance of a few hundred feet. A ring of about ten reinjection wells will be entirely on Tract C-a at a distance in excess of about 4,000 feet from the dewatering wells. Our studies indicate that this system, combined with importation of water so as to reduce consumptive use of upper aquifer water, will result in confining the cone of depression almost entirely within the borders of Tract C-a. Some groundwater, will be used, namely groundwater inflow into the retorts while under production, later will be incinerated. This is an unavoidable consumptive use and we may inject some imported water to offset this withdrawal.

A more detailed description of the dewatering/reinjection system for the MDP will be available in Rio Blanco's subsurface disposal permit application (SDPA) to the Colorado Department of Health (CDH). The SDPA is expected to be submitted to the CDH by about September 1, 1977. A copy will be supplied to the Area Oil Shale Office as soon as it is available.

The dewatering/reinjection system for the Commercial Phase will be designed after obtaining experience with the MDP system.

SCOPE OF WORK

RBOSP MODULAR DEVELOPMENT PHASE
MONITORING PROGRAM
ON TRACT C-a OIL SHALE LEASE

August 17, 1977

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SCOPE OF WORK
RBOSP MODULAR DEVELOPMENT PHASE MONITORING PROGRAM

1.0 INTRODUCTION

This scope of work describes the tasks that are being conducted to fulfill RBOSP's obligations to monitor selected environmental parameters during development of oil shale resources on Tract C-a in northwestern Colorado. The work scope described herein covers a four-year and four-month period as follows:

Year 1 - Sept. - Dec., 1977 (4 months)
Year 2 - Jan. - Dec., 1978 (12 months)
Year 3 - Jan. - Dec., 1979 (12 months)
Year 4 - Jan. - Dec., 1980 (12 months)
Year 5 - Jan. - Dec., 1981 (12 months)

Methods described herein are in accordance with and fulfill obligations stated in the May 1977 RBOSP Revised Detailed Development Plan for development monitoring. Part I of this monitoring program covers routine development monitoring only. Monitoring to be conducted in concert with the revegetation program and habitat enhancement programs will be developed at a later date and submitted as addenda to this scope. Lagomorph studies originally described as a part of the monitoring program have been deleted, since no revegetation of disturbed areas is planned for the period covered by this scope. These studies will be added when revegetation practices are initiated.

Part I of this technical work scope consists of five technical sections:

2.0 Air Quality Studies
3.0 Meteorology Studies
4.0 Terrestrial Studies
5.0 Aquatic Studies

6.0 Hydrology Studies

and three general information sections:

7.0 Management
8.0 Reports
9.0 Schedules

Information on objectives, rationale, methods, and experimental design and data analysis is presented within each technical discipline. Report design and contents and program schedules are presented in the general information sections.

2.0 AIR QUALITY STUDIES

Development of the tract may result in various disturbances to the air environment. The intensity of these disturbances is being measured by monitoring the ambient air on and around the tract on a continuing schedule. Instrumentation which detects selected chemical and physical parameters automatically records data to demonstrate compliance with the applicable air pollution control regulations and provides information necessary to evaluate the impact of tract development on the environment.

2.1 AMBIENT MONITORING

The principle data for the air quality studies are obtained by analyzing samples of the ambient air for specific substances. Materials likely to be introduced into the air from tract development include two broad classes: gaseous and particulate pollutants. Aerosols are classified as either solid or liquid particulate matter.

A. Gaseous Constituents

Gaseous compounds produced by combustion processes and evaporative losses of stored and transferred materials necessary for tract development are measured as follows:

1. Monitoring Parameters - Ambient air measurements of the concentration of the following compounds include:

Sulfur Dioxide
Oxides of Nitrogen
Nitric oxide
Hydrogen sulfide
Carbon Monoxide

In addition to compounds resulting directly from tract development, the concentration of the ambient ozone is also measured. The concentration of nitrogen dioxide is determined by mathematical computation.

2. Objectives and Rationale - The combustion of fossil fuels for the production of energy results in the production of sulfur and nitrogen oxides. Sulfur oxides are known to have an affect on vegetation, and in the presence of water vapor, some effects on materials. The oxides of nitrogen are precursors of smog formation when they are accompanied by hydrocarbons and strong sunlight, and hydrogen sulfide can be generated in off-gas incineration. There are a variety of tract development activities that have the potential for the emission of these compounds which may have effects of the environment. These potential effects range from changes in the growth rate of flora, to visibility.

The use of vehicles during tract development and operations will introduce unburned hydrocarbons, nitrogen oxides, and carbon monoxide into the ambient air. Additional nitrogen oxides and carbon monoxide will result from mine ventilation exhaust. Methane is a natural component of the ambient air and is not considered an air pollutant. Ozone, which is produced by the photochemical reaction of sunlight on atmospheric oxygen is an important component in atmospheric chemistry of other undesirable pollutants.

Ambient air concentrations of most of the chemical components being monitored are continuously regulated by state and federal laws. In order to demonstrate compliance with the applicable regulations, the monitoring data must provide reliable data for presentation to various regulatory agencies. In addition, the data must support other related studies to determine the environmental impact of finite changes in the air environment.

3. Methods - Ambient air gaseous compounds are monitored continually with automated instrumentation. The instruments are housed in environmentally controlled shelters strategically located on and off the tract..

a. Monitoring locations - Monitoring Site 1 (148,500E; 227,034N) just west of the western tract boundary is the location at which the greatest variety of air monitoring data has been obtained. Continued monitoring at this location will provide a continuity with the baseline data set so that long term changes in ambient air quality may be detected. Monitoring will continue at Site 1 during early stages of the MDP. Later, during the third quarter of 1979, Sites 2 and 3 will be activated. Analysis of the baseline data indicated that monitoring Site 2 (153,600E; 214,938N) south of the southwest corner of the tract provides data representative of the air mass entering the tract area from the direction of the prevailing winds. Monitoring Site 3 (166,625E; 227,375N) is located in the approximate center of the drainage valley leading away from the northeast corner of the tract. Baseline meteorological data acquired at this site show that this location is well situated to monitor night-time drainage winds from the tract development area. This location is also subject to frequent inversion conditions that tend to trap low-level emissions, and will provide an adequate measure of air quality under these conditions. Locations and frequencies for development monitoring are shown on Table 1. An additional SO_2 measurement will be taken At Site 6 using a Monitor Labs 8450 Sulfur analyzer or equivalent, beginning in September, 1979 (Table 1).

b. Monitoring frequency and schedule - The instrumentation on site that is presently being used for gaseous component measurements is capable of continuous operation when supplied with reliable commercial power. When the instruments are serviced and maintained on a regular schedule, data recovery should be near 90 percent, annually. This recovery rate exceeds the federally recommended minimum of 75 percent. The automatic data acquisition system installed presently at Site 1 collects a large set of air quality data. This system automatically scans all parameters approximately once each 3 minutes, and computes a running 15-minute and 1-hour average. The data are stored on magnetic tape. All time designations are in local standard time (Mountain Standard), and the seasons of the year are defined as Spring: March, April, and May; Summer: June, July, and August; Fall: September, October, and November;

Table 1. Air Quality Studies Monitoring Schedule

Parameter	Location	Start Date	Frequency
Sulphur Dioxide	Sites 1,3	June 1, 1979	Continuously
Oxides of Nitrogen	Site 1	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Nitric Oxide	Site 1	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Hydrogen Sulfide	Sites 1,3	June 1, 1979	Continuously
Carbon Monoxide	Site 1	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Ozone	Site 1	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Nitrogen Dioxide*	Site 1	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Particulates	Sites 1, 2 & 3	Sept. 1, 1977	Every 6th day
	Sites 4 & 5 (see Figure 1)	Nov. 1, 1977	Every 6th day
SO_2**	Site 6	June 1, 1979	Continuously

* By Mathematical Calculation

** Requires Purchase of New Equipment

and Winter: December, January, and February. Data hours are computed from data acquired during the hour so that the 0200 data point is the average from 0100 to 0200 hours. The 15-minute data averages are not ordinarily utilized, but are available for future requirements if necessary.

c. Data acquisition techniques and instrumentation - Gas detection instrumentation was installed at the monitoring sites two and one half years ago. This equipment has an expected service lifetime of at least three to five more years. On February 18, 1975 the Environmental Protection Agency (EPA) published rulings on Ambient Air Monitoring Reference and Equivalent Methods (FR Vol 40 No 33, February 18, 1975) which defined standards for the detection of certain pollutants for regulatory agencies. The new standards rule out certain detection techniques and instrument designs, but allow a period of five years for their continued use, or under certain conditions, for the rest of their useful life. Future instrumentation designs require a certification of certain test results by the EPA.

The detection techniques in use in the tract instrumentation meet the requirements of reference method specifications, but some of the instrument models have not, and will not, receive certification that their performance meets the published requirements. Frequent calibrations, quality control charts of zero and span drifts, and careful maintenance will provide a demonstration of equivalence in instrument performance for all parameters monitored except sulfur dioxide. The existing instruments (SO_2) are of a fixed sensitivity range which do not provide the required resolution of one percent of full scale. Baseline sulfur dioxide data levels were below the reliable threshold of detection.

Data are recorded with two methods simultaneously. One, the instrument output signal is digitized electronically and averaged by a computer, and recorded on magnetic tape. Two, the instrument output signal is recorded on a channel of a multipoint strip chart recorder. The strip chart data are backup for the magnetic tape data record.

All air quality data are processed by an on-site computer. The computer program has been documented and is on file at Site 1.

d. Data handling and quality assurance procedures - Magnetic tapes and strip chart records are transferred from the site to the NUS data reduction group in Rockville on a bi-weekly basis. The material is logged in, reviewed by an analyst, and filed for batch processing on a quarterly basis. If data are missing from the magnetic tape record, the analyst reduces strip chart data. This involves timing the record and reading the air quality parameters as percent of scale. Documented work instructions defining missing data, determination of hourly averages, minimum detectable level, etc. are used for manual data reduction. Manually reduced data are punched on cards and used to supplement the tape data.

Operation and maintenance of the air quality instrumentation are performed by site technicians. A station log is maintained in which site relevant information is recorded each time the facility is visited. In addition, the technician has a site-specific check list on which to record instrument performance parameters, and a documented work instruction for site surveillance. These records are completed at least once each calendar week. The tests require a zero and span check of all instruments. These dynamic tests consists of switching the instrument sample line from the ambient air intake manifold to a standard gas sample obtained either from a standard gas cylinder or a permeation tube source that has been standardized. A quality control chart is maintained for the results of the zero and span tests. Control limits are established to maintain acceptable instrument performance.

Calibration of the air quality instrumentation is performed at least once each season (90 day period). These calibrations, along with the running control charts are used to establish the instrument sensitivity. The calibrations are performed in accordance with documented work instructions by personnel other than the site technicians. Where appropriate (O_3, SO_2, NO_2, and H_2S) wet chemical determinations are made. Test gases, containing known concentrations of CO, and NO are acquired as

necessary from vendors who can furnish traceability of accuracy to the National Bureau of Standards. The site technician cooperates with the EPA sponsored program "Quality Assurance in Support of Energy Related Monitoring Activities in the Western United States," which provides a quarterly round-robin calibration backup check using independent test gases and instrumentation.

Scale factors for each parameter monitored are established as a result of the calibration results. The calibration data are maintained in a separate log.

4. Experimental Design and Data Analysis Procedures - Air quality will probably be influenced by tract development. In its baseline condition, the air environment of the tract contained only traces of the common urban air pollutants SO_2, NO_x, and CO. There are measurable concentrations of O_3 and NMHC which are relatively constant and appear to be of local, natural origin.

Air quality data for each parameter measured will be examined statistically for frequency of occurence and plotted. This data presentation provides average, standard deviation, 99th percentile, and distribution characteristics of the extra data set. Plotted on a seasonal and annual basis the plots provide a graphic display of differences. The data will also be examined for concentration versus time of day since it is expected that some low level emissions will be trapped under surface based inversion layers and transported by the night-time drainage wind flow away from the tract.

Comparisons with regulatory standards will be made using the cumulative frequency distribution of hourly values. The standards will be plotted on the charges. When, and if, the level of SO_2 increases sufficiently, that data will be plotted for displaying the 3 hour average in comparison with that standard of the Colorado Department of Health.

Mathematical modeling of the dispersion of pollutants in the tract area has been performed. During the development phase monitoring results

will be compared with model predictions prior to installation of full scale facilities. The degree of comparison will depend on the accuracy with which the emission source terms can be determined for the initial facilities.

B. Particulates

During the baseline data acquisition period, data were acquired on the mass concentration, particle size and composition of airborne particulate matter on and near the tract. In general the concentrations were very low, the particle size quite small, and the composition representative of the local ground material. When sampling was conducted in the vicinity of unpaved roads, greater concentrations were observed. Tract development will bring vehicular traffic and site preparation that will increase the suspended particulate concentration.

1. Monitoring Parameters - Total suspended particulate as defined by the EPA in the National Primary and Secondary Ambient Air Quality Standards (40 CFR 50) will be monitored.

2. Objectives and Rationale - Total suspended particulate is a controlled air pollutant. Monitoring is performed at site boundaries to insure compliance with regulations and to determine necessary control actions for fugitive dust control and vehicular traffic.

3. Methods

a. Monitoring locations - A high volume sampler is operated at each of the three air quality monitoring sites at 20 feet above ground elevation. In addition, two high volume samplers are operated at two additional locations (20 feet above ground elevation) generally downwind of current site development activities. These locations are indicated on Figure 1. Particulate measurements will be initiated at Sites 4 and 5 during the fourth quarter of 1977.

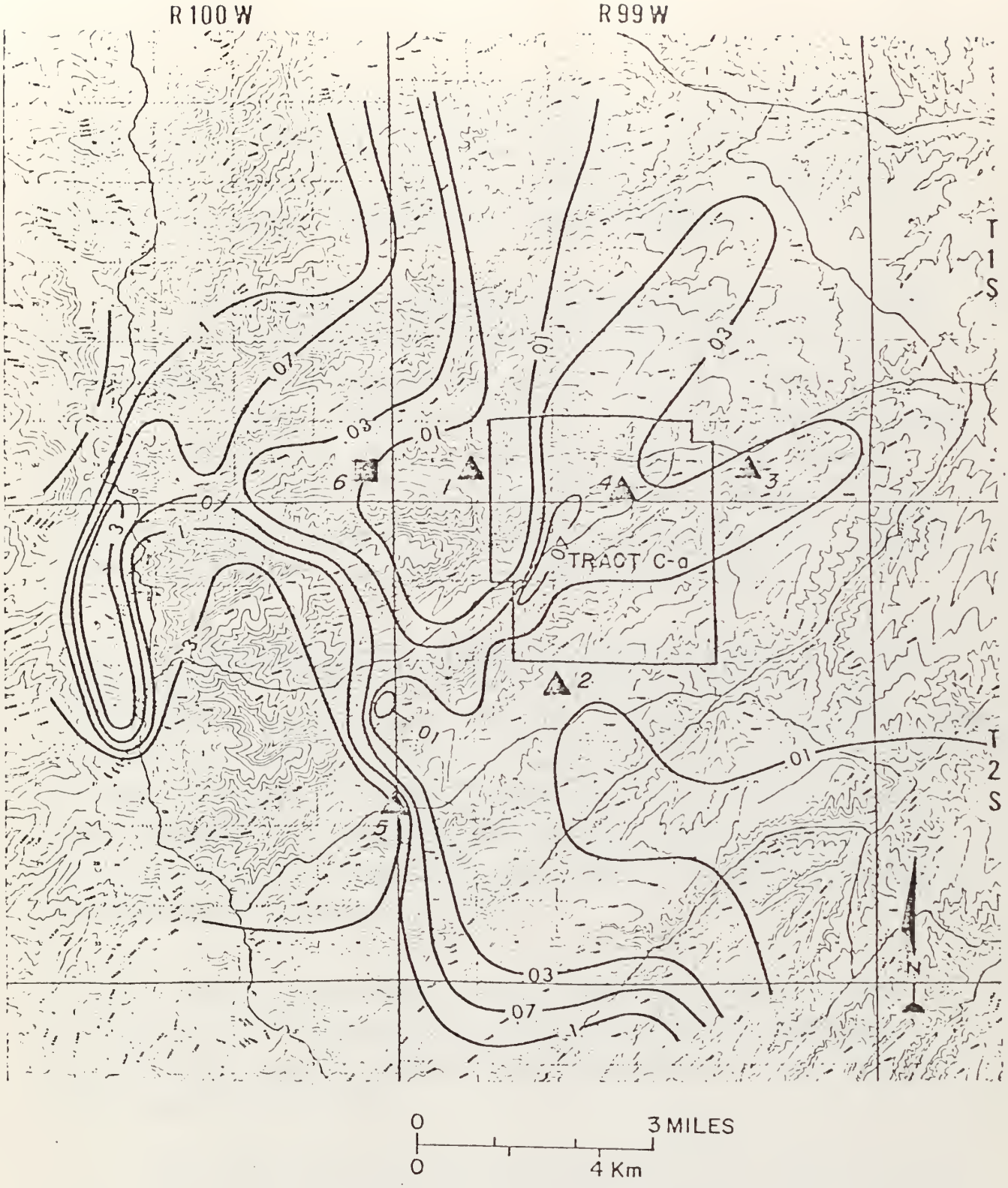


Figure 1. Locations of Hi Vol particulate samplers (▲) and SO_2 sampler (■) for the MDP monitoring program. Isopleths represent predicted annual mean particulate concentrations ($\mu g/m^3$) for the MDP.

b. Monitoring frequency and schedule - One twenty four-hour volume sample is acquired from each of the five samplers every sixth day. A day is defined as 0000 hours to 2400 hours. This is the same schedule as observed in National Air Sampling Network.

c. Data collection techniques instrumentation - General Metal Works high volume samplers with Sierra flow controllers are used to acquire samples. A six-day electric clock timer controls the on-off cycle of the sampler. Unexposed filter mats are conditioned and weighed at the NUS Rockville air quality laboratory using the EPA reference technique. The balance is standardized with class S weights. Filters are coded and supplies to the field technician ready for use. Exposed filters are recycled through the same analytical procedure.

d. Data handling and quality assurance procedures - The high volume sampler flow rates are calibrated quarterly with a standard orifice plate to determine the parameters to be used to calculate particulate concentration. Each exposed filter carries with it a location verifier and before and after flow meter readings taken by the field technician. Weight determinations are maintained in a log in the air quality laboratory and filters are stored for future reference if chemical composition or radioactivity levels are required.

The field technician cooperates with the EPA Western Energy Quality Assurance Program in the parallel calibration of sampler flow rates. The Rockville air quality laboratory also cooperates in inter-laboratory weight standardization tests.

4. Experimental Design and Data Analysis Procedures - The principal purpose of particulate monitoring is to assure compliance with regulatory standards. Additional information may be derived which will assist in evaluating the effectiveness of fugitive dust control measures, traffic patterns to minimize airborne particulate, and the effect of dust deposition on tract vegetation and water surfaces. The visibility, as measured

from or across the tract area may be influenced by tract development activities that result in large scale soil disturbances. The diffusion potential of the afternoon atmosphere is generally high and the small particle size component of surface soil may be distributed widely by the diffusion process.

3.0 METEOROLOGY STUDIES

The dispersion of pollutants in the atmosphere is controlled by the local meteorology of the region of the atmosphere into which the pollutants have been released. Measurements taken during the baseline data acquisition program were intended to measure two distinct meteorological regimes. One, the surface and near surface wind flow, and two, the wind flow more nearly representing the synoptic wind uninfluenced by surface topography. These measurements are continuing.

3.1 AMBIENT MONITORING

Monitoring Parameters

The following parameters are being measured as a continuation of the baseline data acquisition program:

- 10 m and 60 m wind direction, $\pm$ 3^{o} accuracy
- 10 m and 60 m wind speed, 0.5 mph treshold
- 10 m and 60 m wind sigma
- 10 m ambient temperature, $\pm$.05 F accuracy
- 10 m - 60 m differential temperature, $\pm$0.18 F accuracy
- Precipitation, accuracy $\pm$0.01 in
- Solar radiation

B. Objectives and Rationale

The dispersion of emissions into the atmosphere that are a result of tract development of operations is governed by local meteorology. The measurement program in operation provides information useful for determining atmospheric transport and diffusion. With the information in hand, and an estimate or measure of emissions caused by tract operations, it is possible to estimate some short- and long-term exposure factors for objects exposed to the air environment.

Diffusion potential estimates are acquired by calculating the standard deviation of the wind direction vector (horizontal stability) and the measurement of the 10 m - 60 m temperature difference (vertical stability).

C. Methods

1. Monitoring locations - Seven parameters are monitored at air quality monitoring Site 1 which is presently equipped with a 60 m instrument tower. An additional parameter, dewpoint measurement, will be added to the instrument compliment at the onset of tract development activities (Table 2).

Meteorological measurements of wind direction, speed, and ambient temperature will be made at air quality monitoring Sites 2 and 3 with the sensors monitored 10 m above ground level (Table 2).

2. Monitoring Frequency and Schedule - Meteorological parameters are monitored continuously by the automatic data acquisition system, backed up by strip chart recorders. The data acquisition system scans each parameter approximately once each 3 minutes and computes a running 15-minute average. The average value is recorded on magnetic tape at the end of each quarter hour. Hourly averages are computed from the 15-minute values during data reduction.

3. Data Collection Techniques and Instrumentation - All of the present meteorological sensors for wind speed and direction have performance specifications which meet or exceed the average requirements of the Nuclear Regulatory Commission (NRC) Regulatory Guide 1.23. To maintain these specifications, these sensors are replaced quarterly with identical units calibrated by NOIC, traceable to NBS. These sensors are cycled through the calibration and replacement process along with similar sensors used on NUS meteorological monitoring programs.

The temperature sensors are platinum resistance elements that have specifications which meet or exceed the requirements of NRC Regulatory

Table 2. Meteorology Studies Monitoring Schedule

Parameter	Location	Start Date	Frequency
Wind direction (10m)	Sites 1, 2	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Wind direction (60m)	Site 1	Sept. 1, 1977	Continuously
Wind speed (10m)	Sites 1, 2	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Wind speed (60m)	Site 1	Sept. 1, 1977	Continuously
Wind sigma (10 & 60m)	Site 1	Sept. 1, 1977	Continuously
Ambient temperature (10m)	Sites 1, 2	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Temperature (10-60m)	Site 1	Sept. 1, 1977	Continuously
Precipitation (tipping bucket and recording gauge)	Site 1	Sept. 1, 1977	Continuously
Solar radiation	Site 1	Sept. 1, 1977	Continuously
Dewpoint*	Site 1	Sept. 1, 1977	Continuously

* Requires purchase of new equipment

Guide 1.23. To maintain the temperature system accuracy, the system is calibrated against a certified quartz thermometer on a quarterly basis. The temperature measuring elements are exposed to measured absolute and differential temperature baths.

The dewpoint measurement instrument is factory calibrated to an accuracy which exceeds the accuracy requirements of NRC Regulatory Guide 1.23. The dewpoint sensor accuracy is maintained by proper servicing operations in the field.

The precipitation gages (tipping bucket and recording types) are calibrated quarterly by adding precisely measured volumes of distilled water. The accuracy is maintained by keeping the collectors clean, and the mechanical mechanism clean and free of insect intrusion.

The solar radiation sensor is factory calibrated annually. The accuracy is maintained by keeping the collector aperature clean and the field of view unobstructed.

The recording devices are voltage operated and are calibrated with certified test equipment by applying a series of test voltages that permit the determination of sensitivity and viscosity.

The wind sigma measurement is made electronically by integrating the change in wind direction per unit time. This unit is not a sensor, but is operated by sensor derived signals. Calibration of the sigma meter is performed with certified frequency and voltage calibration sources.

The geographic azimuth accuracy of the wind direction sensors is established with sighting telescopes using known landmarks.

4. Data Handling and Quality Assurance Techniques - The meteorological data are recorded on magnetic tape along with air quality for the same time interval. The tapes are returned to NUS for computer listing, scaling, and data fill-in from strip chart reduction where required. The new data are reviewed for reasonableness by a data analyst prior to

processing.

Data processing consists of the following statistical summaries:

- Annual and seasonal wind roses per sensor per location
- Annual and seasonal maximum, minimum and mean values
- Monthly, seasonal and annual precipitation totals
- Frequency of occurence, stability class by sigma and delta T
- Joint frequency distribution: wind speed, direction, and stability, annual

Computer programs for statistical calculations are routinely tested through the NUS Quality Assurance Program.

Tract development activities are not expected to influence site meteorology. There will be, however, differences in the year-to-year meteorology that are due to natural causes. These changes in meteorology may significantly influence air quality.

D. Experimental Design and Data Analysis Procedures

The principal utility of site meteorological data is its application in interpreting observed changes in air quality. The mathematical diffusion model development was based on an assigned meteorological data year (September 1, 1975 - August 31, 1976: Ref OOP-B-5-23). The model predictions of average and short term pollutant concentrations should correlate reasonably well with the monitoring results when allowances are made for variations in meteorological factors. An evaluation can be performed using annual summary air quality and meteorological data that will verify the applicability of diffusion model predictions of ground level pollutant concentrations at points on and around the tract. Once the predictions have been established as valid, guidance in the selection of test areas of maximum ecological impact can be supported.

The observer-based visibility program will be continued to supplement the recommended bi-annual photometric evaluation of visual range. Mean

visibility in the region is expected to be a slowly changing function, if there is a change. Average meteorological factors have a direct effect on long-range visibility (scattering and absorption by water vapor and precipitation scavenging of suspended solids, etc.). If a net change in visibility occurs, it will be interpreted with respect to concurrent air quality and meteorological changes. These studies will be carried out as a cooperative study between Tract C-a and Tract C-b operators at the visibility tower between the two tracts as used during baseline. Studies will be carried out bi-annually beginning in 1978 (Table 3).

Table 3. Visibility* Monitoring Schedule

Visibility Tower		
Parameter	Start Date	Frequency
Visual Range	Spring 1978	Bi-annually

* Not included within current cost estimate

4.0 TERRESTRIAL STUDIES

4.1 ABIOTIC MONITORING

A. Soils

1. Trace Metals

a. Objectives and Rationale - The objective of the trace metal study is to collect soil and vegetation samples which will be stored for trace metal analysis. If source monitoring indicates that trace metals emissions are occuring, these samples will be analyzed for trace metal content. Although projected gaseous and particulate emissions are not expected to contain trace metals, source monitoring is designed to determine if trace metal emissions occur. Soil samples are collected concurrently with the air quality monitoring program.

b. Methods - The projected site of potential impact, if any, is located in an area of estimated maximum concentrations of trace metals. The control site is located south of the tract where minimum concentrations are expected (Figure 2). The control and impact sites each include a 1.5 x 1.5 mile area.

Twenty soil samples will be collected at each site in 1981, the year before commercial operations begin, and annually thereafter. Samples are collected during August from the surface soils (0-10 cm) of each site. Twenty composite samples of sagebrush leaves are collected at each site from the current year's growth (Table 4).

Soil and vegetation samples are stored for a reasonable length of time or until significant levels of trace metals are detected by source monitoring. If significant levels are detected, soil and vegetation samples will be analyzed for Sb, As, B, Cd, F, Hg, Se, Mo, and V.

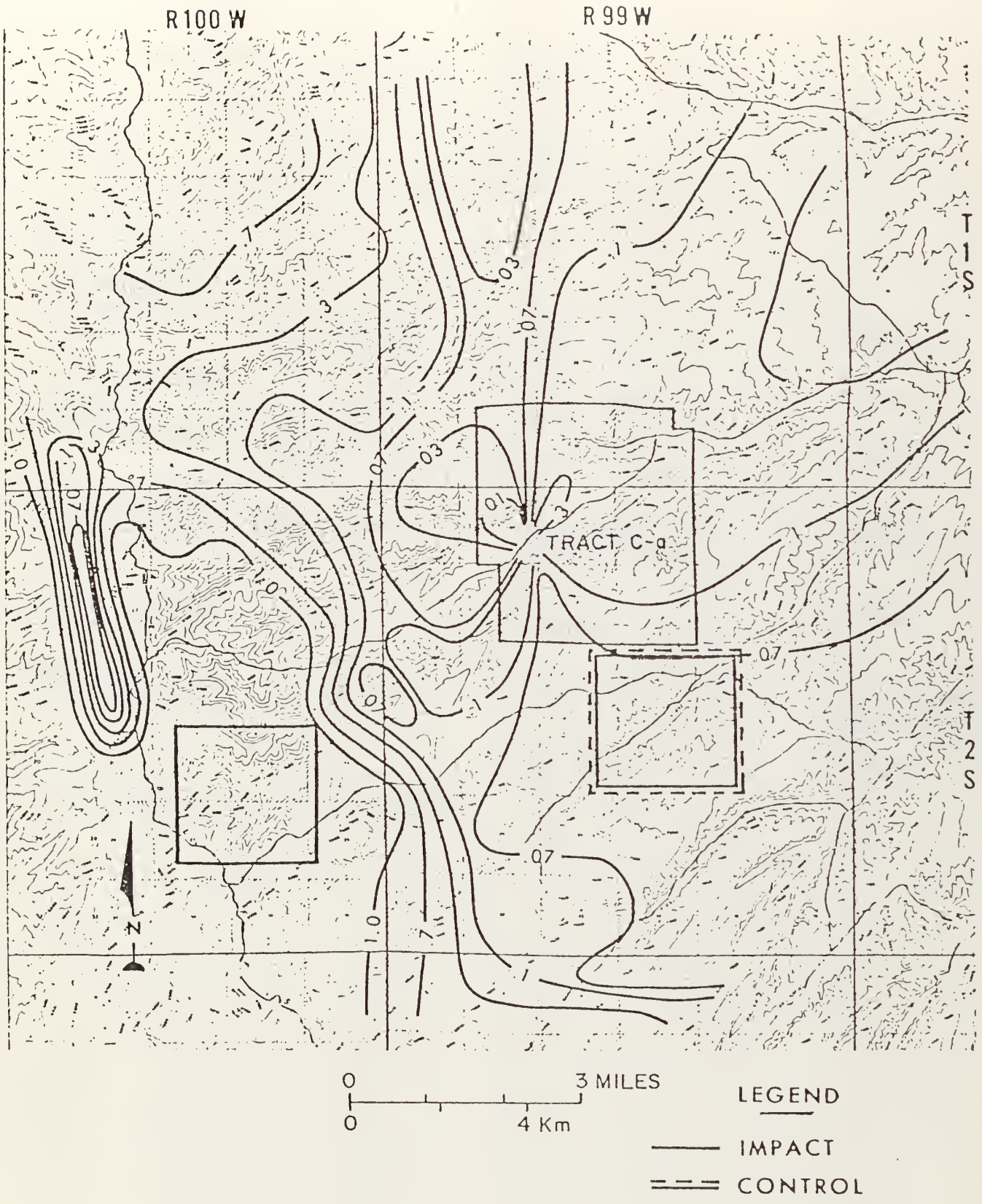


Figure 2. Location of Soil Monitoring Sites Based on Particulate Distribution

Table 4. Terrestrial Studies Monitoring Schedule

Parameter	Location	Start Date	Frequency
Trace Metals (Collection & Storage of soils & vegetation samples)	See Figure 2	Aug. 1981	Annually
Soil Conductivity Studies	See Figure 3	Aug. 1981	Annually
Vegetation Mapping	Tract C-a & 5-mi. Perimeter	May 1978	Annually
Range Productibility & Utilization	See Figure 4	April 1978 (establish plots)	Annually (in Sept.)
Browse Condition & Utilization	See Figure 4	May 1978	Annually
Mule Deer Density Studies	See Figure 5	Sept. 1977	Semi-annually (May, Sept.)
Feral Horse Abundance	Tract C-a & 3-mi Perimeter	Jan. 1978	Annually

c. Experimental design and data analyses - The trace metal study is designed to test the following hypotheses:

H_o: There is no significant difference in trace metal concentrations between the impact and control sites before development; after development.

H_o: There is no significant difference in trace metal concentrations at the impact site before and after development; at the control site before and after development.

Data collected on the control and impact sites are analyzed by an analysis of variance (AOV). Data collected in 1981 will be used to test between site differences. A two-way AOV is used to determine site differences, time effects, and a site x time interaction for data collected after 1981. If the interaction effect is significant, then a multiple range test will be performed to determine the source of the interaction. Data are entered and stored on 9-track, 800 bpi magnetic tape according to documented quality assurance procedures (ESG Quality Assurance Manual, Issue B).

2. Soil Conductivity Studies

a. Objectives and rationale - Projected levels of salt drift from the cooling towers are projected to be low; nevertheless, the soil studies are designed to detect any significant changes in soil salinity or conductivity levels which may be detrimental to plant growth.

b. Methods - Maximum concentrations of salt drift are expected immediately adjacent to the cooling tower. The impact site, a 0.5 x 0.5 mile area, is located adjacent to the cooling towers in the area of maximum deposition (Figure 3). The control site (0.5 x 0.5 mile) is located on tract, east of the plant site (Figure 3). Twenty samples will be collected at random from each site annually in August beginning in 1981, the year prior to commercial operations. Soil samples are collected from the surface soils (0-10 cm) of each site. These samples are analyzed by a commercial laboratory to determine electrical conductivity.

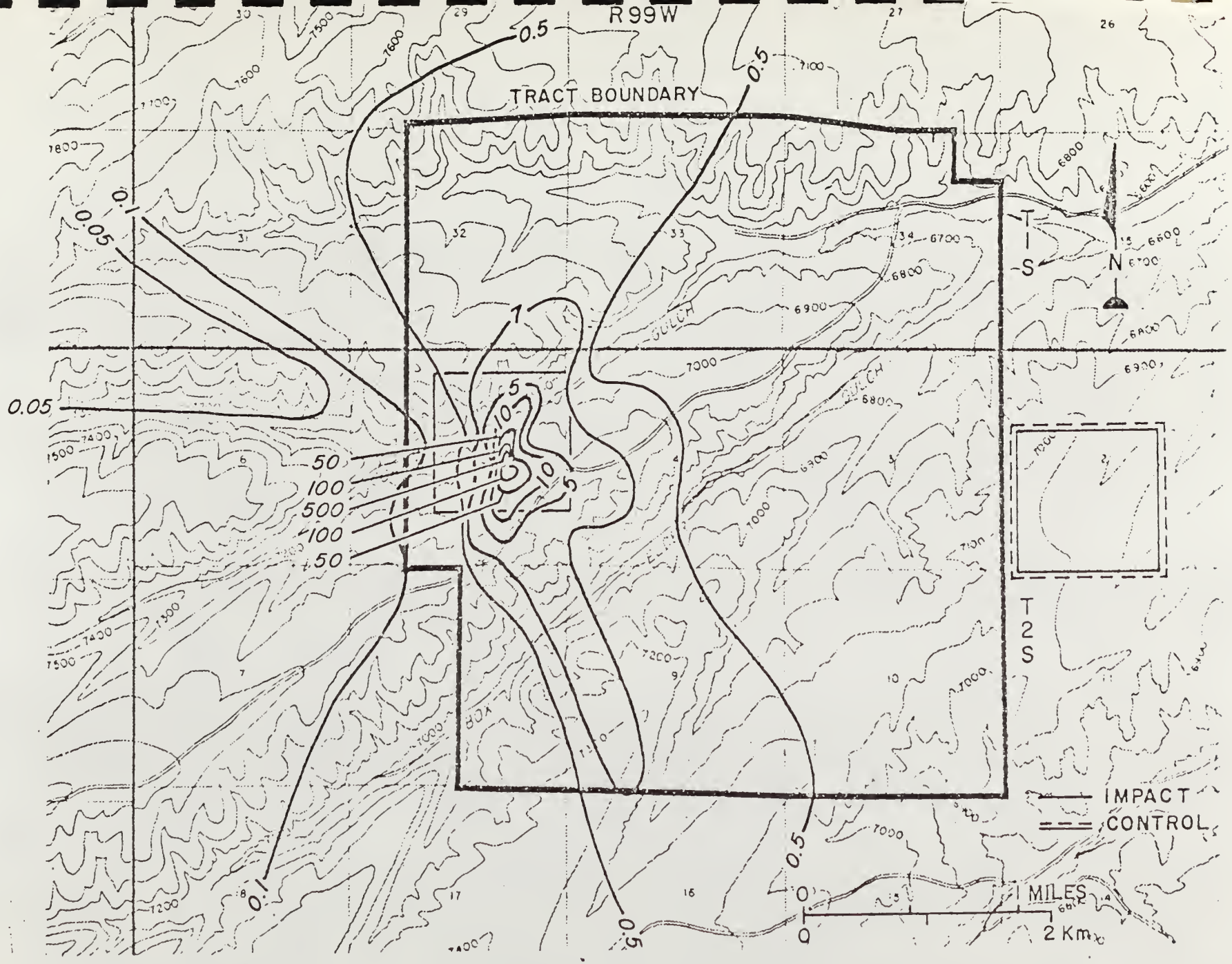


Figure 3. Location of Soil Monitoring Sites Based on Salt Drift Dispersion Pattern

c. Experimental design qnd data analyses - The soil conductivity studies are designed to test the following hypotheses.

H_o: There is no significant difference in the soil conductivity between the impact and control sites before development; after development.

H_o: There is no significant difference in soil conductivity at the impact site before and after development; at the control site before and after development.

Data collected on the control and impact sites are analyzed by means of an AOV. Data collected in 1981 will be used to test between site differences. After 1981, a two-way AOV will be used to compare site differences, time effects, and site x time interaction. If the interaction effect is significant, then a multiple range test will be performed to determine the source of the interaction. Data are entered and stored on 9 track, 800 bpi magnetic tape according to procedures in ESG Quality Assurance Manual (Issue B).

4.2 BIOTIC MONITORING

A. VEGETATION

1. Vegetation Type Distribution

a. Objectives and rationale - Construction and operation at Tract C-a may affect the local distribution of vegetation. This study is designed to monitor the distribution of vegetation in the tract vicinity to determine large-scale changes resulting from Tract C-a development.

b. Methods - Color infra-red aerial photography (1 inch = 2,000 feet scale) is taken annually, beginning in 1978 (Table 4). The photographed area includes Tract C-a and the area within a five-mile radius. The RBOSP vegetation map (RBOSP, 1977) is compared annually to previously taken aerial photographs to determine any changes in the distribution

of vegetation types. If changes are detected, the vegetation map is modified to reflect them.

c. Experimental design and data analyses - This program is designed to provide qualitative information on vegetation distributions since statistical analyses are not appropriate. Vegetation distribution data are presented on a vegetation map which is used as the basis for calculating the acreage of each vegetation type in the study area. Vegetation distribution is compared between years to determine the extent of any potential changes in habitat resulting from Tract C-a development. These data are not computer compatible and are not stored on computer tape.

2. Range Productivity and Utilization

a. Objectives and rationale - The Modular Development Phase (MDP) activities on Tract C-a may affect the animal distribution and, thereby, range use in the vicinity of the tract. The range productivity studies are designed to provide information on vegetative production and forage utilization which can be used to compare range use before and during modular development. Because the potential impacts are projected to be local, the range studies focus on areas on Tract C-a that are adjacent to MDP activities and that were previously used for grazing.

b. Methods - The range sampling sites are selected at random in mixed brush, pinyon-juniper, and sagebrush in the same general location as the browse transects. The distribution of the interim range transects (mixed brush-5, pinyon-juniper-10, sagebrush-15) will be modified to establish 10 transects in each vegetation type. The present five transects located on 84 Mesa will not be sampled during the MDP. The locations of the 30 range sampling transects are presented in Figure 4.

An adequate sampling size, based on present total herbaceous cover, was determined for each vegetation type. These estimates were calculated for each of the six sampling periods in 1975 and 1976 (RBOSP Final Environmental Baseline Report 1977). Based on 1.0 x 0.5 m quadrats, an adequate sampling size (accuracy of $\pm$10% of the mean 90% of the time)

is 302 sample quadrats for mixed brush, 383 for pinyon-juniper, and 403 for sagebrush. However, the extremely high number of sample quadrats required for this level of accuracy is not practical or feasible for development monitoring. Sample size requirements to achieve an accuracy of ± 25% of the mean 90% of the time, are 64 for sagebrush, 49 for mixed brush, and 61 for pinyon-juniper. The range productivity and utilization studies are designed to include 10 transects per vegetation type (10 plots/transect) or a total of 100 plots. This sampling intensity should achieve a minimum accuracy of ± 25% of the mean 90% of the time. The sampling intensity will be evaluated after the first year and the program modified as necessary.

Forage is measured annually at the end of the growing season (September) by the double sampling method (USDA, Region 2, 1970). Two caged plots (9.6 sq. ft. in size), and eight unprotected plots (permanently marked) are located at 10 m intervals along each sample transect. The plots are permanently established in April of the first year, and the two caged plots are moved to new locations each September, following clipping (Table 4). Sampling is done with a 9.6 sq. ft. sampling loop on each of eight unprotected plots. An ocular estimate is made of production (weight to the nearest gram) of the dominant grass and forb species (species making up 90 percent of the individuals) within the loop. The two protected plots are estimated in the same manner. Each species within the protected plots is then clipped, bagged separately, weighed green, and the weights are recorded. Species providing less than one percent of the biomass are recorded as being present, but are not weighed. Correction factors are calculated from the estimated green weights and actual green weights of the clipped plots.

Percent utilization is calculated as follows:

$$\% \text{ Utilization} = \frac{\text{Average Productivity per ungrazed plot} - \text{Average Productivity per graved plot}}{\text{Average productivity per ungrazed plot}} \times 100$$

Damage from insects or frost is qualitatively assessed. Any damage is recorded and an estimate of damaged vegetation is made to determine the percent of the sampled vegetation which is affected.

c. Experimental design and data analyses - The range studies are designed to test the following hypothesis:

H_o: There is no significant difference in vegetative productivity or forage use within a vegetation type before and during modular development.

The range productivity and utilization data are analyzed by an AOV to compare pre-development conditions with those during development.

Data are entered and stored on 9 track, 800 bpi magnetic tape and all data analyses are performed by computer. Data control procedures are outlined in the NUS ESG Quality Assurance Manual (Issue B) for Level 2 projects.

3. Browse Condition and Utilization

a. Objectives and rationale - Tract C-a development may reduce browse availability and therefore affect animal distribution in the vicinity of Tract C-a. The browse condition and utilization studies are designed to provide browse use information for areas adjacent to Tract C-a development.

b. Methods - Browse condition and utilization are measured along 30 transects (mixed brush-10; pinyon-juniper-10, sagebrush-10). The browse transects are located in the same general vicinity as the range transects (Figure 4).

Browse sampling is conducted annually in early May after deer have migrated through the Tract C-a area (Table 4).

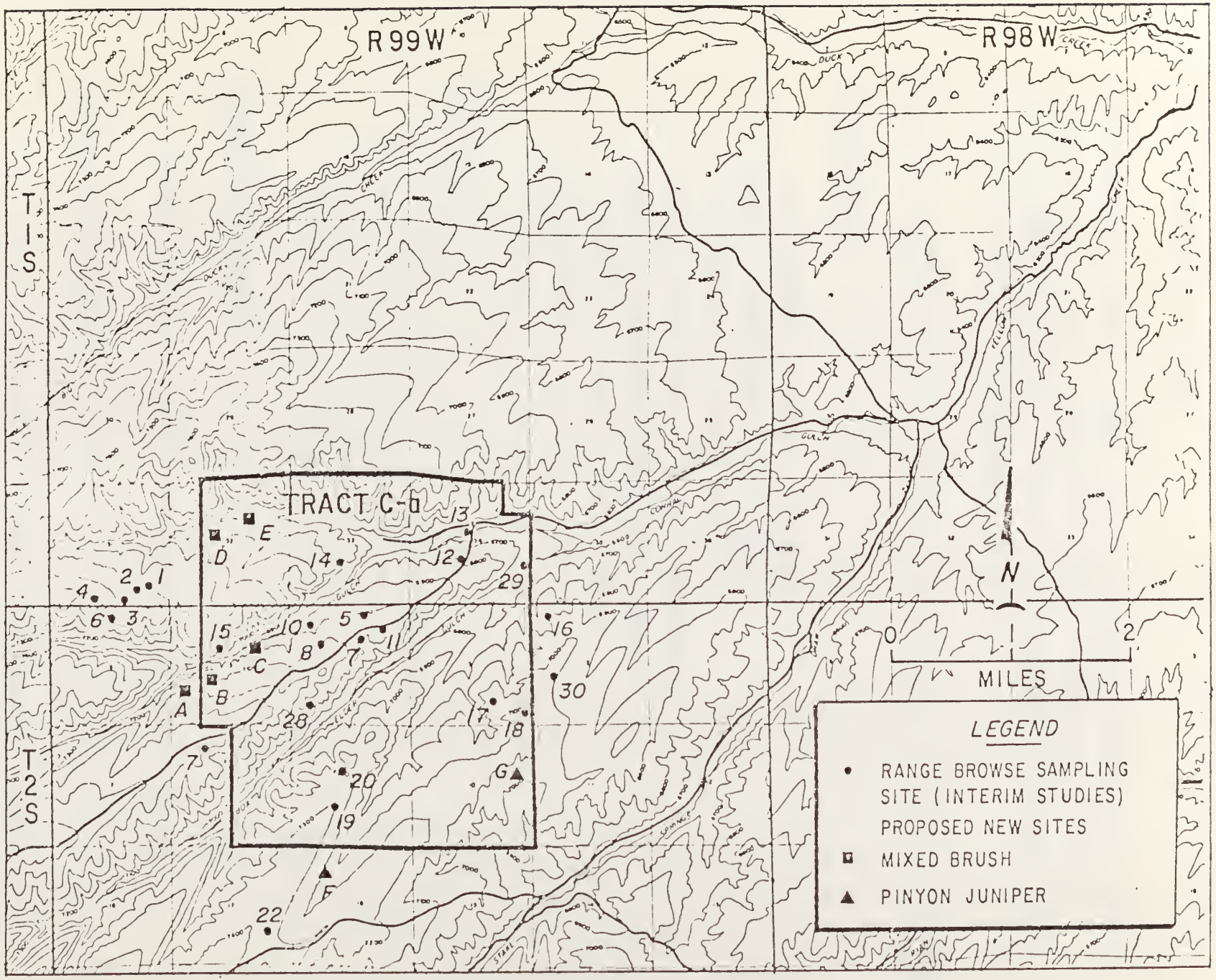


Figure 4. Sampling Sites of Range/Browse and Faunal Interim Monitoring Studies

Browse condition and utilization is estimated along transects consisting of 25 individual shrubs (Cole 1963). Transects are selected at random within each vegetation type.

Browse species sampled include: juniper (Juniperus osteosperma), pinyon (Pinus edulis), antelope bitterbrush (Purshia tridentata), snowberry (Symphoricarpos oreophilus), big sagebrush (Artemisia tridentata), and true mountain mahogany (Cercocarpus montanus).

During field sampling, five parameters are examined and recorded - including:

Form classes:

1. All available, little or no hedging
2. All available, moderately hedged
3. All available, severely hedged
4. Partially available, little or no hedging
5. Partially available, moderately hedged
6. Partially available, severely hedged
7. Unavailable
8. Dead

Age Classes:

S - seedling - less than 0.3 cm basal diameter
Y - young - 0.3 to 0.6 cm basal diameter
M - mature - over 0.6 cm basal diameter
D - decadent - more than 25 percent of crown surface is dead

Leader Use Estimates:

Percent of twigs or leaders which are available and show use

Hedging Classification:

Classification based upon the length and appearance (hedging) of the previous year's growth (the two-year old wood):

1. None to light
2. Moderate
3. Severe

Availability:

Visual estimate of the percent of the plant available to deer as browse, i.e., that portion less than six feet high.

Damage from insects or frost is assessed qualitatively. Any damage is recorded and an estimate of damaged vegetation is calculated to determine the percent of the sampled vegetation which is affected.

c. Experimental design and data analyses - The browse studies are designed to test the following hypothesis:

H_o: There is no significant difference in browse utilization within a given vegetation type before and during development.

The browse utilization data collected in the mixed brush, pinyon-juniper and sagebrush types are analyzed by an AOV. The analysis of variance is used to compare differences before and during development. Browse utilization data collected during the first year are used to determine the number of transects necessary to achieve an accuracy of $\pm$25% of the mean 90% of the time; the sampling intensity will be adjusted to achieve this accuracy.

The browse condition data are class data which are not appropriate for AOV techniques. These data are summarized and qualitatively compared between years.

Data are entered and stored on 9 track 800 bpi, magnetic tape and all data analyses are performed by computer. Data control procedures are outlined in the NUS ESG Quality Assurance Manual (Issue B) for Level 2 projects.

B. Fauna

1. Mule Deer Density

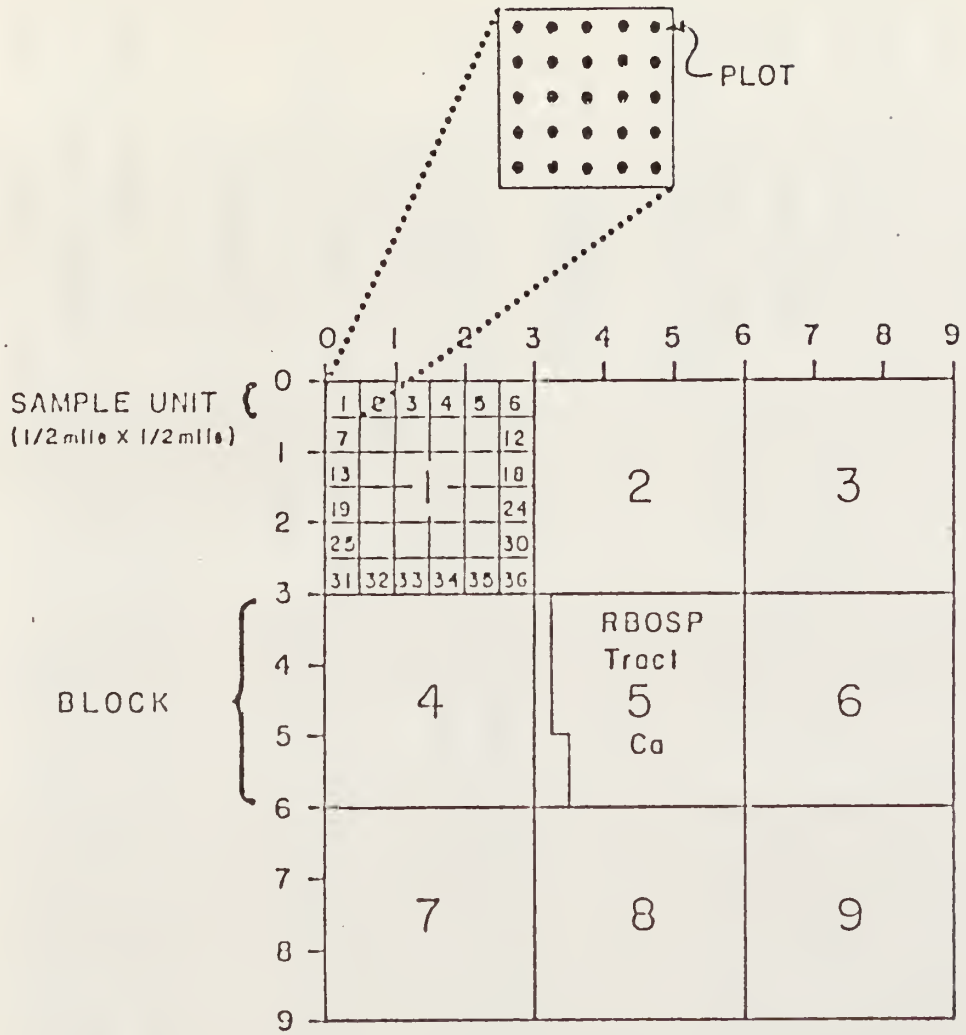
a. Objectives and rationale - Mule deer are the most important game species in Colorado in terms of recreational use and money expended by hunters. The Piceance Creek basin mule deer herd is one of the largest migratory mule deer herds in North America. Tract C-a is within Colorado Division of Wildlife's (CDOW) Game Management Unit 22 (Piceance).

Moderate numbers of mule deer occur on Tract C-a during migration periods, particularly spring, and during mild winters; at other times mule deer are relatively uncommon on the tract. Consideration of the possible effects of Tract C-a oil shale development on mule deer is an integral part of RBOSP's Fish and Wildlife Management Plan.

The objectives of RBOSP's mule deer monitoring program are to obtain an index of mule deer density in a 9 x 9 mile (81 sq mi) study area centered on Tract C-a (Figure 5), to compare mule deer density estimates from the study area with those from Game Management Unit 22, and to compare differences in mule deer densities within various portions of the study area.

b. Methods - Tract C-a is in the center of a 9 x 9 mile (81 sq mi) study area which is divided into blocks (approximately 3 x 3 miles or 9 sq mi each). Quarter sections (160 acres, 64 ha) are randomly selected from each block. The total number of quarter sections chosen depends on the results of initial sampling efforts.

During initial sampling, 25 plots, ca. 100 sq ft (1/1000 ha) each, are systematically spaced within at least 60 randomly selected quarter section sampling units (Figure 5). The boundary of each plot is determined by placing one end of a 5.8 foot (1.78 m) long chain on a center stake and walking around the stake with the opposite end of the chain pulled taut.



plot = ca. 100 square ft (1/1000 ha)
sample unit = 160 acres (ca. 64 ha)
block= 9 square miles

25 plots per sample unit
36 potential sample units per block
9 blocks in the RBOSP Study Area

Figure 5. Study Area for Mule Deer Pellet-Group Counts, RBOSP Modular and Commercial Phase Monitoring Program

Pellet-groups found within the circular plots are counted; to qualify as a group, six or more pellets must be present. Groups on the boundary of a plot are counted if one-half or more of the total number of pellets are within the plot. Sampling plots used during monitoring are marked with a numbered metal stake at the center of each plot. Pellet-group counts are made twice a year, once in the Spring (May), and once in the Fall (September), to determine the number of pellet groups deposited in the summer and during the migration and wintering periods. All pellet groups are removed from the plots before the monitoring studies begin. Actual counting begins with the following sampling period. Each group is marked to differentiate groups deposited during each season. Sampling will start before MDP construction begins and will be conducted during each spring and fall season for the subsequent five years (Table 4).

c. Experimental design and data analysis - Tract C-a is in the center of a 9 x 9 mile (81 sq mi) study area which is divided into blocks (approximately 3 x 3 miles or 9 sq mi each). This area is being studied before and during oil shale development activities. Assessments of potential impacts of development require knowledge of deer distribution and abundance before mining or enhancement activities begin. To this end the following hypotheses will be tested.

Hypotheses

H_o: Mule deer density estimates for RBOSP's 81 sq mi study area are not significantly different from those for Game Management Unit 22 (per unit area).

H_o: Mule deer numbers and distribution within the 81 sq mi study area are not significantly different before and during oil shale development activities.

Initial studies will establish the sample size required to provide mule deer density estimates from pellet-group data (within 10 percent of the mean 90 percent of the time). After these studies, an appropriate number

of quarter section sampling units will be randomly selected within systematically chosen blocks. One pellet-group sampling grid will be established in each sampling unit.

Mule deer density estimates are calculated from pellet-group data. The number of pellet groups per unit area, days of use by deer, and deer per acre in the study area are being determined as described by Overton (1971). These analyses provide an estimate of the number of deer per square mile in the 81 sq mi study area. This estimate will be compared with the CDOW estimate for Game Management Unit 22. If pellet-group data are available from CDOW, density estimates for Unit 22 and the 81 sq mi study area will be compared statistically (i.e., regression analysis, analysis of variance) (Seber 1973).

If data collected from each block are adequate (sufficient number of pellet groups), differences in deer densities between blocks will be compared by an F-test and an analysis of variance. Significant changes in differences between blocks might indicate that oil shale mining is influencing deer distribution.

The feasibility of making statistical comparisons of pellet-group data from the nine blocks depends primarily on the number of plots sampled and the frequency and distribution of pellet groups counted. CDOW is currently conducting experimental pellet-group count studies for mule deer in the Piceance Creek basin. Results of pellet counts, and other CDOW mule deer studies, are being incorporated into RBOSP studies to the extent possible. CDOW studies may provide information useful in determining sample size (i.e., number of sample units and number of plots per sample unit) for the RBOSP studies.

Analyses of mule deer pellet-group data from the interim monitoring program revealed that the number of pellet groups deposited varies greatly between study units. The sample size was small (25 plots of 4 m^2 per study unit)

and the design was not comparable to future programs; thus, the data could not provide meaningful sample size estimates for the long term monitoring studies.

The proposed initial studies include 10 man days for a 3-man field crew (total of 30 man-days). It is anticipated that the crew can establish 100 to 200 plots per day (4 to 8 sample units) and will have established 1,000 to 2,000 plots (40 to 80 sample units) at the end of 10 days. At least 60 sample units will be established during initial studies. The sample size for the long-term program will be determined from the May 1978 data.

All data are stored on computer tapes and all final data analyses will be completed with a computer. Data control procedures are as outlined in NUS ESG Quality Assurance Manual (Issue B) for Level 2 projects.

2. Feral Horse Abundance

a. Objectives and rationale - Feral horses occur on and in the vicinity of Tract C-a. These horses are protected under federal law and are under the jurisdiction of the BLM. Feral horses compete with cattle and, to a lesser extent, with mule deer for available forage. The objective of feral horse monitoring studies is to provide qualitative information concerning the status of feral horses in the RBOSP study area.

b. Methods - Feral horses on Tract C-a and within three miles of the tract boundary (i.e., same study area as mule deer) are counted annually in January. Transects are flown with a light plane, and the location and number of horses observed are recorded. The aerial census data will be supplemented by general observations of horses recorded during other terrestrial ecology studies in May and September (Table 4).

c. Experimental design and data analyses - The total number of horses seen in the study area is compared with the number estimated to

be in the area by state and federal agencies. This information provides a qualitative description of the status of feral horses in the study area.

Hypotheses - No statistical hypotheses are tested (only qualitative data are collected).

5.0 AQUATIC STUDIES

5.1 ABIOTIC MONITORING

A. Physical Measurements

1. Parameters - Physical parameters which are being evaluated in the RBOSP aquatic ecological monitoring programs include: Stream velocity, turbidity, dissolved oxygen, pH, specific conductance, water temperature, depth, width, and stream substrate.

2. Objectives and Rationale - The objectives of taking physical measurements of the Aquatic Monitoring Studies are to monitor selected physical characteristics of the streams at each sampling site and to relate these characteristics to baseline chemical and biological conditions. The physical measurement program also includes those chemical parameters which are measured in conjunction with field sampling operations. The physical parameters selected for these monitoring studies are those which may be influenced by development (e.g., increased siltation and turbidity, decreased flows) and which have been shown to be of particular importance to the aquatic organisms observed during baseline studies.

3. Methods

a. Monitoring locations - The sampling sites (also utilized during baseline studies, Figure 6) for the aquatic ecological monitoring program include:

- Station 5 (pond habitat) in Stake Springs Draw.
- Station 7 (spring brook habitat) at the USGS gaging station in Corral Gulch (west).
- Station 13 (spring brook habitat) at the USGS gaging station in Corral Gulch (east).
- Station 14 (pond habitat) in Corral Gulch (east).

Figure 6. Aquatic Ecology Development Monitoring Sampling Sites.

In addition, sampling sites on Yellow Creek and the White River will be monitored to permit evaluations of the effectiveness of RBOSP water quality control plans and the potential impact of development. These sampling sites include:

- Station 20 (spring brook habitat) at the USGS gaging station on Yellow Creek.
- Station 22 (spring brook habitat) on Yellow Creek just above confluence with White River.
- Station 23 (back channel habitat) in the White River.
- Station 27 and 29 (back channel habitats) near the confluence of Yellow Creek with the White River.
- Station 35 (riffle habitat) in the White River.

b. Monitoring frequency and schedule - Sampling, at least initially, is being conducted five times a year to allow comparison of monitoring and baseline data. Sampling is scheduled for October 1977 and April, June, July, August, and October 1978. During subsequent years, sampling will be carried out in April, June, July, August, and October (Table 5).

c. Data collection methods - The following methods are used to determine selected physical characteristics at each sampling site. These determinations are made concurrently with the collection of chemical and biological samples. Stream velocity is measured with a Gurley flowmeter or equivalent. The stream substrate is visually classified at each station at the same time as benthic samples are collected. The turbidity of each sample is determined with a Hach Photometric Turbidimeter or equivalent. Field measurements of dissolved oxygen are made according to the Alsterberg (Azide) modification of the Winkler Method (American Public Health Administration, APHA, 1971).

Other parameters (and methods of measurement) which are determined in the field include pH (portable meter), specific conductance (portable meter), water temperature (thermister or equivalent), depth, width, and total alkalinity (colorimetric; APHA, 1971).

Table 5. Aquatic Studies Monitoring Schedule

Parameter	Location	Start Date	Frequency
	Abiotic DS		
Physical Measurements			
Stream Velocity Turbidity Dissolved Oxygen PH Specific Conductance Water Temperature Depth Width Stream Substrate	Stations 5,7,13,14 20,22,23,27,29,35 (See Figure 6)	Oct. 1977	5 times/year (April,June, July, Aug.,Oct.)
Water Quality Measurements			
Boron Calcium Chloride Fluoride Magnesium Nitrate Orthophosphate Potassium Total Phosphate Silica Sulfate	Stations 27,29 (See Figure 6)	Oct. 1977	5 times/year (April, June, July, Aug., Oct.)
	Biotic DS		
Periphyton	Stations 5,7,13,14 20,22,23,27,29,35 (See Figure 6)	Oct. 1977	5 times/year (April, June, July,Aug., Oct.)
Benthos	Stations 5,7,13,14 20,22,23,27,29,35 (See Figure 6)		5 times/year (April, June, July,Aug., Oct.)

d. Data handling and quality assurance - Data are entered and stored on 9 track, 800 bpi, magnetic tape. Level 2 quality assurance controls as defined in ESG Quality Assurance Manual (Issue B), will be implemented.

4. Experimental Design - In fulfilling the objectives of these studies, the following hypothesis will be tested:

H_o: There is no significant difference in the physical characteristics of surface waters between the baseline and the development monitoring periods

This hypothesis will be tested using analysis of variance techniques. Sampling will be performed to achieve an accuracy of $\pm$ sigma of the mean 80% of the time.

B. Water Quality Measurements

1. Parameters - The following selected water quality parameters are included in the RBOSP aquatic ecological monitoring program: boron, calcium, chloride, fluoride, magnesium, nitrate, orthophosphate, potassium, total phosphate, silica, and sulfate.

2. Objectives and Rationale - The objectives of this aspect of the aquatic monitoring studies will be to monitor those chemical characteristics which baseline data analyses (RBOSP Final Environmental Baseline Report 1977) have shown to contribute most to the natural variability in White River water quality in order to assess natural and man induced variability in water quality. Water quality studies in other surface waters are included in hydrology studies (Section 6.0).

3. Methods

a. Monitoring locations - The following sampling sites (Figure 6) are included in the White River water quality monitoring program:

- Station 27 (above the confluence with Yellow Creek).
- Station 29 (below the confluence with Yellow Creek).

b. Monitoring frequency and schedule - Sampling, at least initially, is conducted five times a year to allow comparisons of monitoring and baseline data. Sampling is scheduled for October 1977 and April, June, July, August, and October 1978. During subsequent years, sampling will occur in April, June, July, August, and October (Table 5).

c. Sample collection and analysis - Table 6 lists the analytical methods, limits of detection, and methods of sample preservation for the water quality parameters.

d. Data handling - Data are entered and stored on 9 track, 800 bpi, magnetic tape according to procedures outlined in ESG Quality Assurance Manual (Issue B).

4. Experimental Design - In fulfilling the objectives of these studies, the following hypotheses will be tested.

H_o: There is no significant difference in the water quality characteristics of the White River between the baseline and development monitoring periods.

H_o: There is no significant difference in the water quality characteristics among sample sites.

These hypotheses will be tested using analysis of variance techniques. Sampling will be performed to achieve an accuracy of $\pm$ sigma of the mean 80% of the time.

Table 6. RBOSP White River Water Quality Analyses

Parameter	Methodology	Sample Preservation
Boron	APHA[1] 405A	None Required
Calcium	Atomic Absorption	None Required
Chloride	Potentiometric	None Required
Fluoride	Electrode	None Required
Magnesium	Atomic absorption	HCl
Nitrate	APHA[1]419C	$HgCl_2$
Orthophosphate	EPA[2]	$HgCl_2$
Potassium	Atomic absorption	HCl
Total Phosphate	EPA[2]	$HgCl_2$
Silica	APHA[1]	HCl
Sulfate	APHA[1]427C	Refrigeration

[1] American Public Health Association (APHA)

[2] Environmental Protection Agency (EPA)

Note: Samples will be retained for three months following submission of the year-end report.

5.2 BIOTIC MONITORING

A. Periphyton

1. Parameters - Periphyton species composition, relative abundance, biomass, and diversity are the parameters included in RBOSP periphyton monitoring studies.

2. Objectives and Rationale - The objectives of periphyton studies are to monitor periphyton species composition, relative abundance and diversity to assess the effects of development on periphyton communities. Periphyton are monitored because:

- Periphytic algae constitutes a major source of allochothonous primary production in the study area streams
- They are non-motile and therefore provide a good indication of physical and chemical changes at a given location
- Changes in species composition, standing crop, and diversity can be used to assess the effects of site development (e.g. erosion and resulting sedimentation)

3. Methods

a. Monitoring locations - The same monitoring sites identified in section 5.1.A.3 are utilized for RBOSP periphyton studies.

b. Monitoring frequency and schedule - Sampling frequency, at least initially, will be five times a year to allow comparison of monitoring and baseline data. Sampling is scheduled for October 1977 and April, June, July, August, and October 1978 and will occur in April, June, July, August, and October during subsequent years (Table 5).

c. Sample collection and analysis - At each site, a total of four replicate samples is collected. Two of these are used to determine relative abundance and the remaining two are used to determine biomass.

Samples of periphyton are collected from areas of equivalent flow, where possible. Rocks that have relatively flat upper surfaces and are positioned at mid-depth in riffles are selected for the collection of periphyton samples. The rocks are carefully removed from the streams and each replicate is taken by removing the periphyton from a 50 cm^2 area with a toothbrush and water (Northern States Power Co. 1974). The resultant suspension of material is preserved in 5 percent neutralized formalin.

In the laboratory, the preserved periphyton samples are diluted to a constant volume and an aliquot removed, centrifuged, and washed with distilled water. The samples are then dehydrated and stained in the centrifuge, using successive spinnings and decantings. A series of stains and alcohol is then used for the periphyton. A number of drops of the final xylene-periphyton suspension is placed on a microscope slide with Hyrax, heated gently, and covered with an ultra-thin coverglass. The final mounts are retained in the permanent voucher collection. See Aquatic Annual Report for methods (RBOSP, 1976).

Periphyton is counted using a microscope from one randomly chosen transect at 1000X (oil immersion). All organisms appearing in this field are identified and counted. The whole slide is then surveyed at 100X to identify and enumerate larger rare species. Counts are expressed as cells per unit area; these data are used to compute relative abundance and species diversity.

Biomass determinations are made by drying the samples at a constant temperature of 105 C and weighed, then ashed at 550 C (Vollenweider 1969). The ash-free dry weights are calculated as an estimate of the organic weight or biomass of the periphyton. Samples will be retained for three months following submission of the year-end report, then destroyed. A voucher collection will be maintained, however.

Biomass per unit area is calculated from biomass determinations.

d. Data handling - Data are entered and stored on 9 track, 800 bpi, magnetic tape according to quality assurance procedures documented in ESG Quality Assurance Manual (Issue B), level 2.

4. Experimental Design - In fulfilling the objectives of these studies, the following hypotheses are being tested:

H_o: There is no significant difference in the relative abundance of periphyton between the baseline and development monitoring periods.

H_o: There is no significant difference in periphyton diversity between baseline and development monitoring periods.

H_o: There is no significant difference in the relative abundance of periphyton among sites.

H_o: There is no significant difference in periphyton diversity among sites.

These hypotheses are tested by using analysis of variance techniques. Sampling is being performed to achieve an accuracy of $\pm$ sigma of the mean 80% of the time.

B. Benthos

1. Parameters - During the RBOSP development monitoring, benthos species composition, relative abundance, and diversity are being determined.

2. Objectives and Rationale - The objectives of the benthic (macroinvertebrate) studies during the monitoring program are to monitor benthic species composition, relative abundance, and diversity to assess the effects of development on benthos communities. Benthic studies are included in the RBOSP development monitoring program because benthic macroinvertebrates constitute the major component of the secondary trophic level in aquatic ecosystems on and near Tract C-a, and because of their limited mobility and consequent susceptibility to physical and chemical changes.

3. Methods

a. Monitoring locations - The same monitoring sites identified in section 5.1.A.3 are utilized for RBOSP benthic studies.

b. Monitoring frequency and schedule - Sampling frequency, at least initially, will be five times a year to allow comparison of monitoring and baseline data. Sampling is scheduled for October 1977 and April, June, July, August, and October 1978 and will occur in April, June, July, August and October during subsequent years (Table 5).

c. Sample collection and analysis - At each sampling site, duplicate samples are collected using a modified Surber sampler. In most cases the modified Surber sampler is used since it has been proven effective in rubble and gravel substrates and yields quantitative results during baseline studies.

After collection, benthos samples are washed in buckets with bottoms fitted with a U.S. Standard No. 30 sieve, and preserved with neutralized 10 percent formalin. Samples will be retained for three months following submission of the year-end report.

Standardized methods of sample processing and analysis are utilized in the laboratory. The benthic samples are first rinsed in 20 cm No. 60 sieves with light-pressure fine spray to remove specimens from rocks and any fine sediments. The samples are then hand sorted under dissecting microscopes at 6X magnification. Organisms are removed from the sample with forceps, eye droppers and probes to petri dishes or watch-glasses containing water. Samples are systematically searched, the examined portions being pushed aside. Unidentified material is also removed along with the organisms and examined under dissecting microscopes. The organisms are stored in plastic capsules (in 70 percent ethanol) within 4-dram vials for a given sample are stored together.

With few exceptions, benthic organisms are identifiable to the generic level without the use of special preparation. Organisms are identified to the lowest taxon possible. Identifications of individuals are usually

made under the dissecting microscope or with temporary slides (under water) using a compound microscope.

Chrinomoidae and Oligochaeta are cleared in xylene and then mounted on permanent slides in Canada balsam. Only complete oligochaetes with intact anterior portions are enumerated.

After identification and enumeration, specimens are separated by lowest identifiable taxon and stored in sample jars in 70 percent ethanol, collectively by sample replicate. A special reference or voucher collection is maintained apart from other specimens.

Only those individuals which are living at the time of collection, as indicated by presence of fleshy tissue, are enumerated for the purpose of estimating populations. Empty mollusc shells, exuvia, reproductive structures, etc. are retained as aids in identification and compilation of qualitative species lists, but are not used for estimates of population densities.

d. Data handling - Data are entered and scored on 9 track, 800 bpi, magnetic tape according to Level 2 quality assurance procedures documented in ESG Quality Assurance Manual (Issue B).

4. Experimental Design - In fulfilling the objectives of these studies, the following hypotheses are being tested:

H_o: There is no significant difference in the relative abundance of benthic macroinvertebrates between the baseline and development monitoring periods.

H_o: There is no significant difference in benthic diversity between the baseline and development monitoring periods.

H_o: There is no significant difference in the relative abundance of benthic macroinvertebrates among sites.

H_o: There is no significant difference in benthic diversity among sites.

These hypotheses are tested by using analysis of variance techniques. Sampling is being performed to achieve an accuracy of $\pm$ sigma of the mean 80% of the time.

6.0 HYDROLOGY STUDIES (Wright Water Engineers, Inc.)

This hydrology monitoring program is based on the data collected during the two-year baseline program. These data have been studied using statistical methods including frequency analysis, scattergram analysis, bivariant correlation, factor analysis, discriminant function, and trend analysis. These studies are summarized in RBOSP Final Environmental Baseline Report (1977) and presented in detail in the appendices of RBOSP Progress Report 10 (1977).

The data collected during this monitoring program are to be compared to the baseline using the same statistical methods as those used for the baseline data. If anomalies are indicated, the source of the anomaly will be analyzed through the statistical methods discussed above. Analysis of such anomalies will be used to determine both changes in the baseline hydrology as well as possible hydrologic environmental effects. With the commencement of tract development, new information may be available which could indicate a need for a modification in this proposed monitoring program.

6.1 SURFACE WATER MONITORING

A. Springs and Seeps

1. Monitoring Parameters - Flow, conductivity, temperature, and pH are measured quarterly (Table 7).

2. Objectives - The objectives of monitoring and observing major springs and seeps during the activities are to determine if their flows and conductivity are affected by dewatering and reinjection.

3. Methods - One of the best methods to measure flowing water is by using a weir or a flume. Therefore, one of these devices is maintained at six major springs and seeps located around Tract C-a (Figure 7). These measurements are made quarterly. The rationale for measuring flows

Table 7. Summary Hydrology Monitoring Program

	Continuously	Quarterly	Semi-Annually
SURFACE WATER			
Stream Gaging Stations 1			
Sediment (periodically)	x (6)		
Conductivity	x (6)		
Temperature	x (6)		
Flow	x (6)		
Limited water quality (pg. 55)		x (6)	
Baseline water quality (pg.56)			x (6)
Springs and Seeps 1			
Flow		x (6)	
Conductivity		x (6)	
Temperature		x (6)	
pH		x (6)	
GROUNDWATER			
Alluvial Holes 1			
Water Levels	x (3)	x (5)	
Limited water quality		x (8)	
Baseline water quality			x (8)
Dual Aquifer Monitor Holes			
Water levels	x (4)		
DEWATERING WELLS			
Flow	x (12)		
Sediment 2 (periodically)	x		
pH 2	x		
Temperature 2	x		
Conductivity 2	x		
Water level alarm	x (12)		
REINJECTION WELLS			
Water level alarm	x (12)		
Baseline water quality 2			x

( ) Indicates the number of samplings sites
1 When water is present.
2 Composite sample before reinjection

Note: Samples will be retained 30 days following submission of year end report.

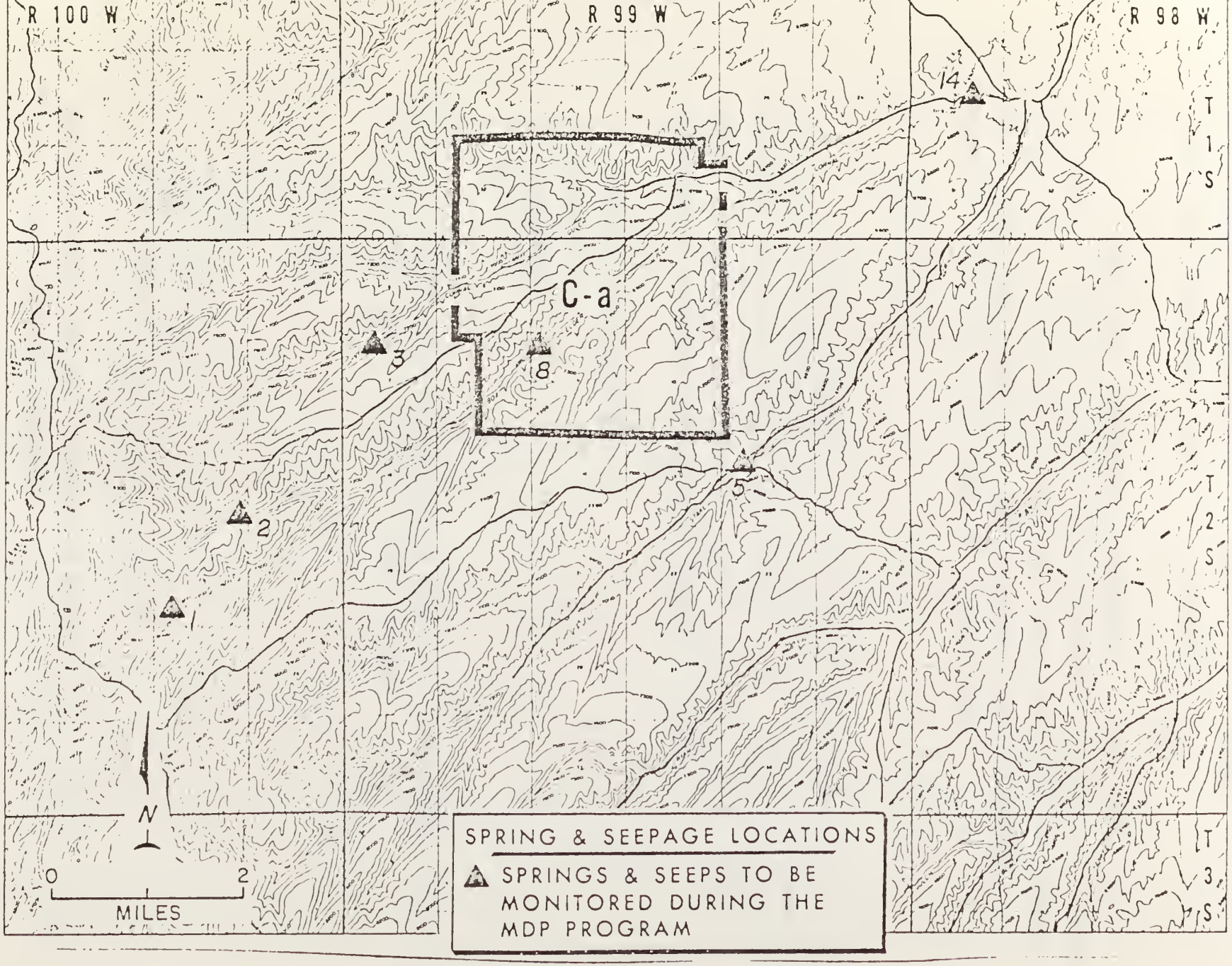


Figure 7. Springs and seeps to be monitored during the MDP

from springs and seeps is based upon analysis of two-year baseline data, which indicated that four of the springs and seeps studied in detail are hydrologically connected to the upper oil shale aquifer.

4. Experimental Design and Data Analysis - This information is analyzed to determine seasonal trends and possible influence by dewatering/reinjection. The nature of the data will determine statistical methods to be used for data analysis. Data are submitted on 9 track 800 bpi magnetic tapes once annually with the year-end report.

B. Surface Water

1. Monitoring Parameters - selected physical and chemical parameters are measured at intervals as shown in Table 7 to provide a comprehensive development monitoring data base on surface water. Data are collected either continuously, quarterly, or semi-annually as shown in Table 7. Continuously collected surface water parameters include:

Sediment (Periodically)
Conductivity
Temperature
Flow

Surface (limited) water parameters are measured on a quarterly basis at all sites where water is present. These include:

Alkalinity
pH
Sodium
Silica
Fluoride
Major ions (Ca, Mg, So_4, Cl, K, HCO_3)

Sodium and the major ions are measured quarterly and used for a cation-anion balance as a quality control check on lab work.

Semi-annual analyses are performed on the following (baseline) constituents at all six surface water gaging stations where water is present. These include:

Bromide	Ammonia	pH
Alkalinity	Bicarbonate	Temperature
Biological Oxygen Demand	Carbonate	Total Phosphate
Dissolved Organic Carbon	Chloride	Ortho Phosphate
Boron	Color	Suspended Organic Carbon
Calcium	Dissolved Solids	Barium*
Conductance	Kjeldahl Nitrogen	Beryllium*
Fluoride	Nitrate Plus Nitrite	Germanium*
Magnesium	Odor	Gallium*
Potassium	Dissolved Phosphate	Nickel*
Silica	Turbidity	Titanium*
Sodium	Dissolved Oxygen	Vanadium*
Chemical Oxygen Demand	Phenols	Zirconium*
Fecal Coliform	Sulfide	Aluminum
Pesticides	Radioactivity	Arsenic
Polycyclic Aromatics	Gross Alpha	Cadmium
Total Coliform	If>4 pci/l	Chromium
Molybdenum*	Then Ra^{226}	Selenium
Strontium	Natural Uranium	Mercury
Cyanide	Gross Beta	Zinc
MBAS	If >100 pci/l	Copper*
Oil & Grease	Then Sr^{90}	Iron
Sulfate	Ce^{137}	Lead
	Lithium*	
	Manganese*	

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* By spectrographic methods only; others by standard wet chemical methods to EPA or detectable limits already established.

2. Objectives

The objectives of the surface water monitoring are to determine if surface water quantity and quality are affected by the Tract C-a MIS mining and construction of associated facilities.

3. Methods

Surface water quantity and quality are monitored through the use of six surface water gaging stations (Figure 8).

A. (09306237) Dry Fork near west line Tract C-a
B. (09306235) Corral Gulch near west line Tract C-a
C. (09306240) Box Elder Gulch near west line Tract C-a
D. (09306242) Corral Gulch east of Tract C-a
E. (09206255) Yellow Creek near White River, Colorado
F. (09206241) "Rinky Dink" Gulch near east line Tract C-a

Monitoring of conductivity, temperature, and flow on a continuous basis; the quarterly monitoring of the major ions (Ca, Mg SO_4, Cl, K, HCO_3, CO_3) and sodium, fluoride, silica, pH, and alkalinity; and the semi-annual analyses for the complete set of baseline constituents (see p. 56) will be adequate to determine changes in baseline parameters (Table 7).

If the continuously recorded parameters (conductivity, temperature, sediment, flow) at D (09306242) exceed the one percentile value for cumulative frequency distribution for baseline data for over three days continuously, the water will be sampled and analyzed for the sodium, fluoride, silica, pH, and the major ions (discussed above) in order to determine from which of the aquifer sources, if any, the anomaly had resulted. If it is determined that the anomaly was due to some other activity, then the complete set of semi-annual analyses will be conducted (p. 56).

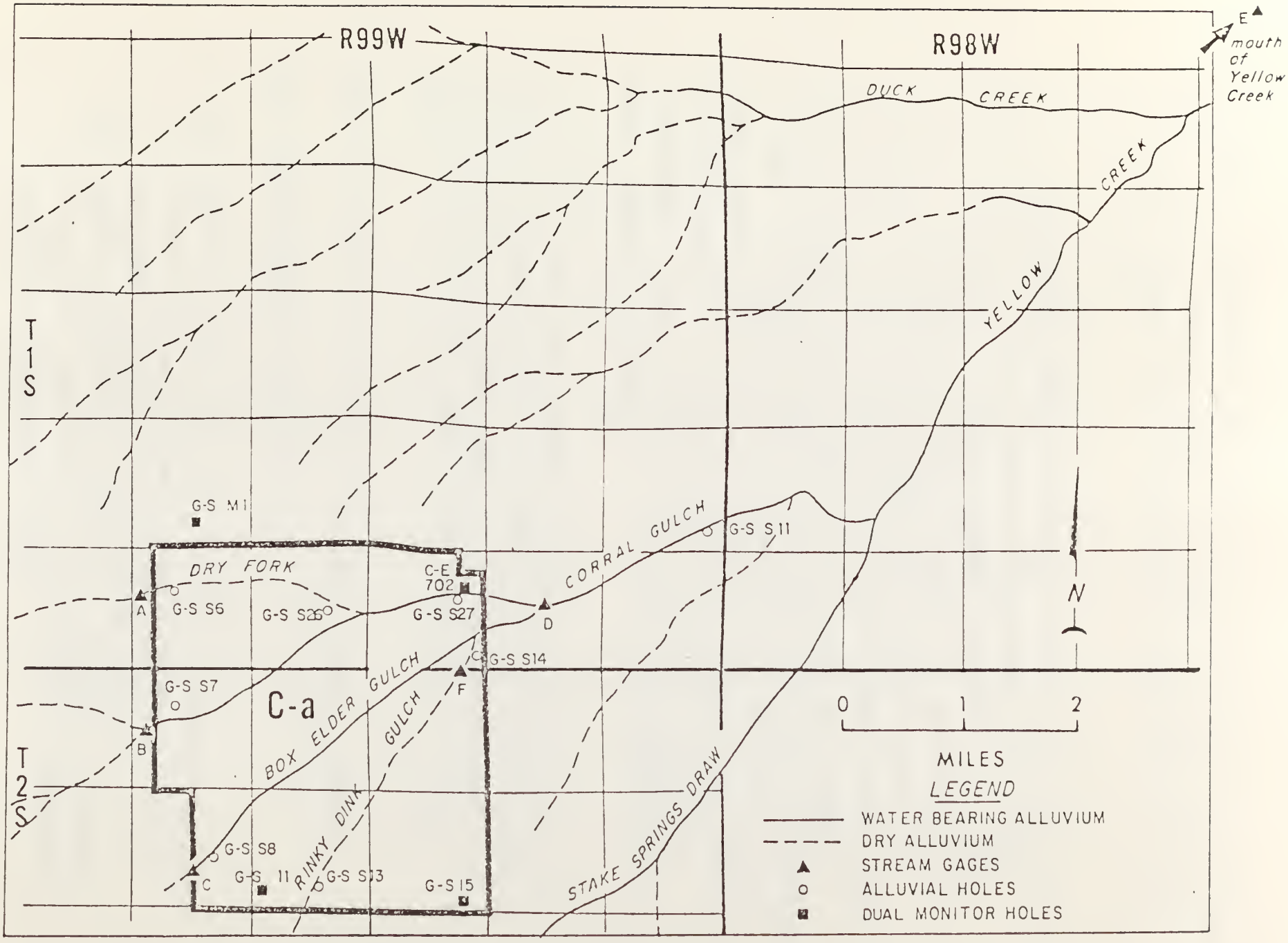


Figure 8. Locations of monitoring stations for hydrology studies during the MDP

As potential by-products, gases, and other possible inputs to the hydrologic system are known, these parameters may be added to the monitoring program. Additional knowledge of possible inputs will be gained during the early portion of the MDP.

4. Experimental Design - Discriminate function analysis was used during the baseline program to develop classification equations that allowed identification of the source aquifer for unknown samples from Tract C-a. The discriminate function developed for the samples with a known source can be applied to samples with an unknown source (i.e., surface water or spring samples) to get the most probable source for the sample in question. The efficiency of the classification function is measured by the percent of samples from a known source that are correctly classified. The function based on concentrations of alkalinity, sodium, silica, fluoride and pH, was used to classify 85 percent of the samples from known sources. If the upper aquifer and alluvial aquifers are grouped, then the discrimination of lower aquifer water approaches 90 percent probability of success.

The major ions found during baseline studies in the various waters were plotted on trilinear diagrams. The catagorization of waters by calcium, magnesium, sulfate, chlorine, potassium, bicarbonate, carbonate, silicon dioxide and fluoride will allow for additional comparison of water types.

Chemical and physical parameters will undergo correlation studies.

The following hypotheses shall be tested:

H_o: There is no significant difference in the chemical composition of the surface water parameters studied during baseline and development periods at each monitoring station.

H_o: There is no significant difference in the physical parameters of the surface water measured during baseline and development periods at each monitoring station.

6.2 GROUND WATER MONITORING

A. Alluvial Aquifers

1. Monitoring Parameters - Selected physical and chemical parameters are measured at various intervals to provide a comprehensive alluvial aquifer development monitoring data base. Data are collected either: continuously, quarterly, or semi-annually (Table 7).

Water levels will be continuously recorded at three (GS S-7, GS S-26, GS S-27) alluvial monitor holes during the MDP monitoring program.

Alluvial aquifer parameters will be measured at eight locations (Figure 8) on a quarterly basis. Parameters to be measured include:

- Water level
- Alkalinity
- Temperature
- pH
- Conductivity
- Sodium
- Silica
- Fluoride
- Major ions (Ca, Mg, So_4, Cl, K, HCO_3)

The major ions and sodium will be measured and used for a cation-anion balance as quality control check on the lab work.

Semi-annual analyses will be performed on the following (baseline) parameters at all stations when water is present:

- Water level
- Alkalinity
- Cyanide
- Chemical Oxygen Demand
- Selenium
- Silica

Aluminum	Dissolved Solids	Sodium
Ammonia	Germanium*	Strontium
Arsenic	Gallium*	Sulfate
Barium*	Fluoride	Sulfide
Beryllium*	Iron	Titanium*
Bismuth*	Lead	Vanadium*
Bicarbonate	Lithium*	Zirconium*
Bromide	Magnesium	Zinc
Boron	Maganese*	Color
Dissolved Organic Carbon	Mercury	Odor
Calcium	Molydenum*	pH
Carbonate	Nickel*	Temperature
Cadmium	Nitrate plus Nitrite	Conductance
Chloride	Phenols	Radioactivity
Chromium	Dissolved Phosphate	Gross Alpha If >4 pci/l Then Ra^{226} Natural Uranium
Copper*	Potassium	Gross Beta If >100 pci/l Then Sr^{90} Ce^{137}

*By spectrographic methods only, others by standard wet chemical methods to EPA or detectable limits already established.

2. Objectives - The objectives of monitoring the alluvial aquifers are to determine if conditions have changed since the baseline data were collected and to detect impacts caused by accidental oil spills or releases of dewatering water into the alluvial aquifers.

3. Methods - During the baseline period, a total of seven shallow alluvial monitor holes was drilled and monitored. The monitoring of six holes plus two new alluvial holes (Figure 8) will meet the objectives of the MDP monitoring program.

Water level is measured continuously at the two new holes GS S-26 and GS S-27, and GS S-7 by water level recorders. In addition, samples are collected and analyzed quarterly for alkalinity, pH, sodium, silica, fluoride, conductivity, temperature, and the other major ions (Ca, Mg, SO_4, Cl, K, HCO_3). The alluvial holes are sampled and analyzed for all baseline constitutents (listed above) twice a year.

One of the new alluvial holes, GS S-26, is located downstream from the proposed mine shaft retention pond, and the second new alluvial hole, GS S-27, is located on Corral Gulch downstream from all surface disturbances (Figure 8). GS S-14 was monitored during baseline and monitoring of this hole will continue to establish continuity between baseline and development.

As other possible inputs to a hydrologic system are known, these may be added in the monitoring program. Additional knowledge of possible inputs will be gained during the early portion of the MDP.

4. Experimental Design - Discriminant function analysis was used during the baseline program to develop classification equations that will allow identification of the source aquifer for unknown samples from Tract C-a. The discriminant function developed for the samples with known source can be applied to samples with an unknown source (i.e., surface water or spring samples) to get the most probable source for the sample in question. The efficiency of the classification function is measured by the percent of samples from a known source that are correctly classified.

The major ions found during the baseline in the various waters have been plotted on trilinear diagrams. The categorization of waters by calcium, magnesium, sulfate, chloride, potassium, bicarbonate, carbonate, silicon dioxide, and fluoride will permit for additional comparison of water types.

Chemical and physical parameters will undergo correlation studies.

The following hypotheses will be tested:

H_0: There is no significant difference in chemical composition of the alluvial water measured between baseline and development periods.

H_0: There is no significant difference in the physical parameters of the alluvial water measured between baseline and development periods.

B. Deep Oil Shale Aquifers

1. Monitoring Parameters - Ground water is monitored as necessary to establish trends caused by dewatering and reinjection. Water levels are measured continuously at four locations, M1, CE 702, G-S 11 and G-S 15. Continuous composite water quality measurements for dewatering well and mine drainage discharges will include:

Sediment
pH
Conductivity
Temperature

Analysis of baseline water quality constituents will be conducted semi-annually on a composite of dewatering well discharge. These include:

Alkalinity
Aluminum
Ammonia
Arsenic
Barium*
Beryllium*
Bismuth*
Bicarbonate
Bromide
Boron
Dissolved Organic Carbon
Calcium
Carbonate
Cadmium
Chloride
Chromium
Copper*
Cyanide
COD
Dissolved Solids
Germanium*
Gallium*
Flouride
Iron
Lead
Lithium*
Magnesium
Manganese*
Mercury
Molybdenum*
Nickel*
Nitrate plus Nitrite
Phenols
Dissolved Phosphate
Potassium
Selenium
Silica
Sodium
Strontium
Sulfate
Sulfide
Titanium*
Vanadium*
Zirconium*
Zinc
Color
Oder
pH
Temperature
Conductance
Radioactivity
Gross Alpha
If > 4 pci/l
Then Ra^{226}
Natural Uranium
Gross Beta
If >100 pci/l
Then Sr^{90}
Ce^{137}

*By spectrographic methods only, others by standard wet chemical methods to EPA or detectable limits already established.

Reinjection water will be monitored for the parameters required at the frequency described in the sub-surface disposal permit to be issued by the Colorado Department of Health.

2. Objectives - The purpose for this groundwater monitoring is to measure water levels in the upper and lower oil shale aquifers, and to monitor any possible changes in water quality in the upper aquifer.

3. Methods - Flow meters will be used in the dewatering wells to determine dewatering rates. Alarms will be used to determine the water level in each dewatering and reinjection hole.

The rationale for limiting water quality monitoring to discharges only is based on the fact that a cone of depression will be created by dewatering. Water entering the upper aquifer from Tract C-a during dewatering will flow toward the dewatering wells and the mine. Therefore, any effects on water quality will be observed in the discharge waters.

4. Experimental Design - The major ions found during baseline studies in the various waters have been plotted on trilinear diagrams. The catagorization of waters by calcium, magnesium, sulfate, chloride, potassium, bicarbonate, carbonate, silicon dioxide and fluoride will allow for additional comparison of water types.

Chemical and physical parameters will undergo correlation studies.

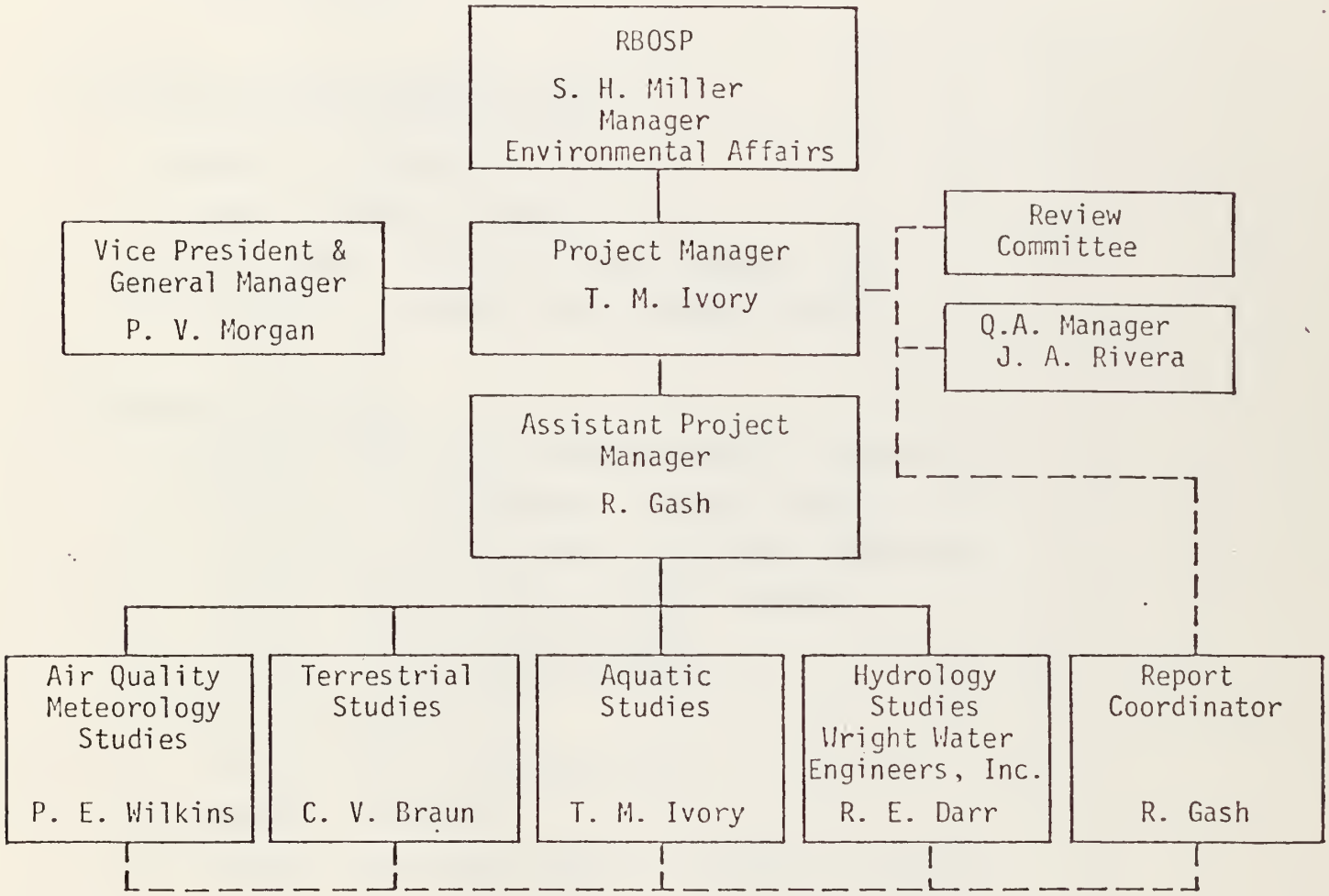
The following hypotheses will be tested:

H_o: There is no significant difference in chemical composition of the deep groundwater between baseline and development periods.

H_o: There is no significant difference in the physical parameters of the deep groundwater between baseline and development periods.

7.0 MANAGEMENT

The responsible corporate office for NUS Corporation is Mr. Paul V. Morgan, Vice President and General Manager, Ecological Sciences Division. The Project Manager for this project is Dr. Thomas M. Ivory, who has served as Project Manager during the interim studies. He will be assisted by Ms. Rosielea Gash as Assistant Project Manager. The organization for the project is as follows:



Other NUS personnel who are involved, in various degrees, with the MDP Monitoring Program include:

Review Committee:

P. V. Morgan - Chairman, Vice President and General Manager, Ecological Sciences Division (EcSD)

J. J. DiNunno - Vice President and General Manager, Environmental Safeguards Division (ESD)

P. Goldstein - Vice President and General Manager, Cyrus William Rice Division

Air Quality - Meteorology Monitoring:

R. Capirci - Site Meteorologist

C. Minehan - Laboratory Technician

D. Holder - Technical Support

S. K. Breslauer - Assistant General Manager, ESD

R. S. Daniels - Assistant General Manager, ESD

Terrestrial Monitoring;

J. W. Clark - Pittsburgh Coordinator/Wildlife Specialist

J. G. Gleich - Section Manager for Fauna Studies

R. J. Eastmond - Section Manager for Vegetation Studies

D. P. Reagan - Small Mammal, Avifauna Specialist

K. E. Ohlson - Vegetation/Taxonomist

T. R. Rojahn - Vegetation/Cartographer

K. D. Hough - Vegetation

W. J. Duncan - Small Mammals/Avifauna

B. Pinkowski - Avifauna

H. A. Haerer - Discipline Manager - Terrestrial Studies

Aquatic Monitoring Studies

D. E. Ruiter, Field Supervisor

T. L. Ruiter, Technical Aide

W. R. Cody, Aquatic Biology

M. Afzal - Aquatic Biology

B. C. Marcy - Discipline Manager - Aquatic Studies

Hydrology Studies

M. Warner - Section Leader

M. J. Chaparro - Technical Support

In addition, Dr. J. S. Warner, Utah State University, serves as a special consultant for the project.

Wright Water Engineers Staff for Hydrology Studies may include: M. J. Smith, Senior Geohydrologist; B. Douglas, Geohydrologist; and C. J. Goewert, Groundwater hydrolgist.

8.0 REPORTS

Mid-year data reports are submitted on August 15 (or nearest work day following the 15th) of each program year (Table 8). Mid-year reports contain reduced and raw data collected during the specified reporting period and short narrative descriptions of results. Where appropriate, (e.g., Air Studies program) data are placed on magnetic data tapes. One copy of each edited tape is submitted for data collected during the previous six months when the mid-year report is submitted.

The year-end report is submitted on February 15 (or nearest work day following the 15th) for each program year. Year-end reports contain raw and reduced data for the previous reporting period (see table, yearly summaries, analyses and interpretations of the 12-month data set, and, where appropriate, comparisons between years, seasons, and other data sets (e.g., DOW data). The year-end report is designed to continually update the data base for the tract. Trends are rated, anomalies are flagged, and long term evaluations are made. Developmental perturbations are identified, and assessed as they occur. Once identified, possible mitigation procedures are recommended.

Table 8. RBOSP Monitoring Program Report Schedule

Report	Data Collection Period[1]	Report Submittal Date
Monitoring Report 1	Sept. - Nov. 1977	Feb. 15, 1978
Monitoring Report 2	Dec. 1977 - May 1978	Aug. 15, 1978
Monitoring Report 3	June - Nov. 1978	Feb. 15, 1979
Monitoring Report 4	Dec. 1978 - May 1979	Aug. 15, 1979
Monitoring Report 5	June - Nov. 1979	Feb. 15, 1980
Monitoring Report 6	Dec. 1979 - May 1980	Aug. 15, 1980
Monitoring Report 7	June - Nov. 1980	Feb. 15, 1981
Monitoring Report 8	Dec. 1981 - May 1981	Aug. 15, 1981
Monitoring Report 9	June - Dec. 1981	Feb. 15, 1982

1/ Data not received during the reporting period will be reported in the report for the period following receipt.

9.0 SCHEDULE

(See map pocket)

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SCHEDULED ACTIVITIES FOR THE RBOSP DEVELOPMENT MONITORING PROGRAM

1977 (YEAR 1) | 1978 (YEAR 2) | 1979 (YEAR 3) | 1980 (YEAR 4) | 1981 (YEAR 5) | 1982

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- WORK SCOPE PREPARATION AND APPROVAL
- CONTRACT NEGOTIATIONS
- DATA ACCUMULATION
  - AIR (SITE 1)
  - (SITES 2&3)
  - TERRESTRIAL
    - SOILS
    - VEGETATION
      - MAPPING
      - RANGE
      - BROWSE
    - FAUNA
      - DEER
      - HORSES
  - AQUATIC
    - ABIOTIC
    - BIOTIC
  - HYDROLOGY
    - SURFACE WATER
      - SPRINGS AND SEEPS
      - GAGING STATIONS
    - GROUNDWATER
      - ALLUVIAL AQUIFERS — ALSO SEE TABLE 7
      - DEEP OIL SHALE AQUIFERS — ALSO SEE TABLE 7
- DATA REDUCTION AND ANALYSIS
  - AIR
  - TERRESTRIAL
    - SOILS
    - VEGETATION
      - MAPPING
      - RANGE
      - BROWSE
    - FAUNA
      - DEER
      - HORSES
  - AQUATIC
    - ABIOTIC
    - BIOTIC
  - HYDROLOGY
    - SURFACE WATER
      - SPRINGS AND SEEPS
      - GAGING STATIONS
    - GROUND WATER
      - ALLUVIAL AQUIFERS
      - DEEP OIL SHALE AQUIFERS
- REPORTS
  - MONTHLY
  - SEMI-ANNUAL
  - SPECIAL STATUS

CONTINUOUSLY

AS NECESSARY

OVER A ONE MONTH PERIOD

Form 1279–3
(June 1984)

BORROWE

IN 859 .L64 R582 197/
Gulf Oil Corporation.
Supplemental material
Revised detailed

DATE LOANED	BORROWER

USDI – BLM